SPECTRACOM CORPORATION
ROCHESTER, NEW YORK • USA

279-5

MODEL 8163

WWVB RECEIVER/COMPARATOR

279-5

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MODEL 8163

WWVB RECEIVER/COMPARATOR

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SPECTRACOM CORPORATION
320 N. Washington Street
Rochester, New York 14625

WARRANTY REGISTRATION

Dear Customer,

Spectracom occasionally contacts customers regarding our products. We must know to whom we should send manual updates, change notices, and new product information. Because people sometimes change job assignments, we request department, mail station, and title information to ensure that correspondence in future years will reach either the user of our products or his/her supervisor. In filling out the registration, please use the title/mail station/department of the supervisor most interested in keeping the equipment and its documentation up-to-date. Thank you.

- -

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CERTIFICATE OF TRACEABILITY

SPECTRACOM CORPORATION hereby certifies that its Model 8163 NBS Frequency Standard Receiver provides direct traceability to the National Bureau of Standards reference frequency as transmitted by station WWVB in Fort Collins, Colorado, with carrier frequency of 60 KHz.

Automatic verification is provided by the station-identifying phase shift of 45^{o} that appears on the carrier signal at 10 minutes after each hour, returning to normal five minutes later. This phase shift appears in the readout as an offset of about 2.1 microseconds on the front panel meter and on the strip chart recorder trace.

When properly installed and maintained, the Model 8163 provides measurement accuracy and resolution as published in the equipment's instruction manual.

SPECTRACOM CORPORATION

WARRANTY

Spectracom Corporation warrants to the original purchaser each new instrument to be free from defects in material and workmanship for a period of one year after shipment. Repair or replacement, at our option, will be made when our examination indicates that defects are due to workmanship or materials. Electron tubes, batteries, fuses, and lamps that have given normal service are excluded from warranty coverage. All warranty returns must first be authorized in writing by the factory.

This warranty does not apply to any of our products which have been repaired or altered by persons not authorized by Spectracom Corp. or not in accordance with instructions furnished by us. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, or if any serial number or seal has been removed or altered, the warranty is void and repairs will be billed at cost.

This warranty is in lieu of all other obligations or liabilities expressed or implied and Spectracom Corp. neither assumes nor authorizes any person to assume for them, any other liability in connection with sales of its products.

REPAIR AND MAINTENANCE

Instruments should be returned only upon prior written authorization from Spectracom Corp. or its authorized sales and service representative. Warranty repair will be made upon written request. Please provide the following information in order to enable us to serve you efficiently:

1. Model Number and type
2. Serial Number
3. Description of trouble
4. Conditions and hours of use

Upon receipt of this information our service department will send you service data or shipping instructions. Transportation to the factory is to be prepaid by purchaser.

For assistance contact your nearest Spectracom sales representative.

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SECTION 1

8163

INSTALLATION

1.0 Introduction

2.0 Unpacking

3.0 Reshipment

4.0 Antenna Location

5.0 Antenna Installation

6.0 TM-500 Mainframe

1.0 INTRODUCTION

The Spectracom Model 8163 WWVB Receiver/Comparator is a frequency calibration instrument that can be used to calibrate standard oscillators to an accuracy of 1×10^{-11}. The calibration is directly traceable to the National Bureau of Standards. The Spectracom Model 8206 ferrite loop antenna is used with the Model 8163.

The Model 8163 receives the 60 KHz signal transmitted by the National Bureau of Standards in Fort Collins, Colorado. Phase locked signals of either 0.1, 1.0, 5.0, or 10.0 MHz are switch selectable at the NBS OUTPUT connector.

The internal phase comparator compares the phase of the LOCAL INPUT signal with the received signal. The comparator operating frequency is switch selectable to one of the four standard frequencies of 0.1, 1.0, 5.0, or 10.0 MHz. The front panel meter displays the relative phase drift between the NBS signal and the LOCAL INPUT. The meter range is normally set to 50 microseconds full scale. An internal switch changes the scale to 10 microseconds full scale.

An auxillary output jack provides drive for an external strip chart recorder for long-term monitoring of oscillator drift.

Green and red go/no-go lamps indicate signal reception and phase locking to the WWVB carrier.

The instrument fits in a Tektronix TM-500 Mainframe and occupies a single plug-in space.

2.0 UNPACKING

In the event of damage to the shipping carton or if there is hidden damage to the equipment, but the carton is not damaged, be sure to contact the carrier immediately so that his representative can witness any equipment damage that may exist inside the carton. If you fail to report shipping damage immediately you may forfeit any claim against the carrier. You should also notify SPECTRACOM CORPORATION of shipping damages so that we can assist you in obtaining a replacement or to repair the equipment.

Be sure to remove all items of equipment and accessories from the shipping carton before discarding it. This includes an ancillary kit and an instruction manual.

3.0 RESHIPMENT

If it is necessary to return the unit to the factory, the original shipping carton may be used. If it is not available, a carton of at least 250# test corrugated paper with at least two inches of polyethylene foam surrounding the unit must be used. The unit should be sealed in a plastic bag for moisture protection and a note must be included stating the reason for the return.

4.0 ANTENNA LOCATION

The antenna should be mounted a minimum of 25 feet from the receiver to prevent regeneration. The antenna MUST NOT be positioned next to the receiver or on top of it. If it is, results obtained with the equipment are meaningless even though the green lock lamp on the receiver front panel may be lit.

The antenna must be at least three feet from any steel beams, roof decking, pipes, etc., as metal will detune the antenna and can cause as much as 20 dB degradation of the signal-to-noise ratio. The antenna must not be mounted under a metal roof or inside a building with heavy steel structural supports, as these shield the antenna from the signal. Roof tops are generally good if a clear shot toward Fort Collins is available without being blocked by a large steel structure. Attics are ideal sites if the roof and rafters are not metallic. The signal-to-noise ratio will be optimized if the antenna is located as far as possible from local RF noise sources such as large electric motors, power lines, oscilloscopes, TV sets, or fluorescent or neon lamps that blink or sputter on and off. Any equipment containing a switching power supply is a probable cause of interference.

5.0 ANTENNA INSTALLATION

The antenna should be mounted where it will not be disturbed, supported by a non-metallic pipe such as one-inch PVC water pipe. Holding the antenna two or three feet off the ground or rooftop is adequate in most cases. The tubular housing must be positioned broadside to Fort Collins, Colorado, where the transmitter is located (see Figures 1-1 and 1-2), and horizontal to the ground, to allow maximum signal reception. No signal will be received if the tube points directly toward the transmitter site, as the antenna pattern nulls are located off the ends of the tube. The antenna position may be optimized using the signal strength measurement described in the Operation Section of this manual.

When the lead-in coaxial cable (RG-58/U is recommended) is connected from the BNC connector on the antenna to the BNC connector on the receiver the system is ready for use, if the antenna has been installed and aimed properly. The antenna has a built-in preamplifier inside its housing that receives its DC operating voltage through the coaxial calbe, therefore both the center conductor and the shield of the cable must be continuous from the antenna to the receiver. A short circuit in this line will not harm the equipment as the power supply is adequately protected.

6.0 TM-500 MAINFRAME

The Model 8163 fits into a single plug-in space in a Tektronix TM-500 Mainframe.

TO AIM ANTENNA AT FORT COLLINS, COLORADO, DETERMINE COMPASS HEADING FROM THIS MAP.

Draw a straight line from the receiver location through Fort Collins, Colo. at the center of the map. Continue until the line intersects the outer ring. The point at which the line intersects the outer ring indicates the compass heading for Fort Collins from your location.

FIG. 1-1 GREAT CIRCLE MAP CENTERED ON FORT COLLINS, COLORADO

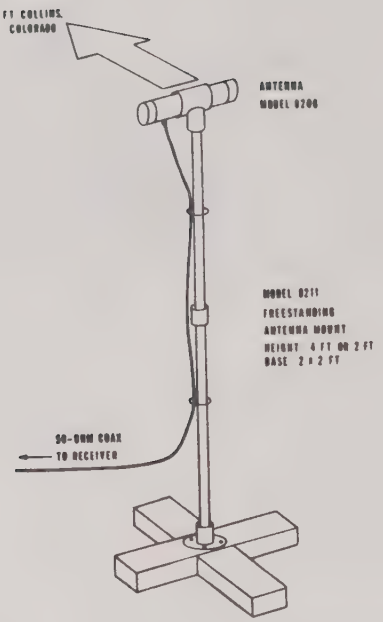


FIG. 1-2 ANTENNA MOUNT MODEL 8211

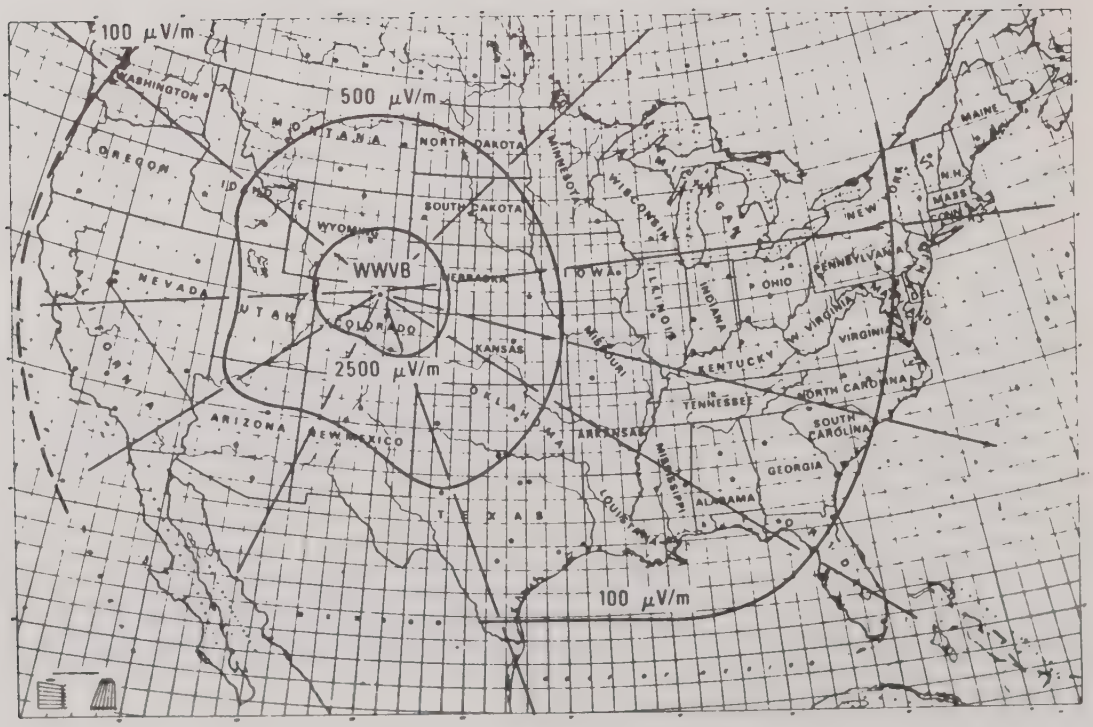


FIG. 1-3 MEASURED FIELD INTENSITY CONTOURS: WWVB @ 13 KW ERP

SECTION 2

8163

OPERATION

1.0 Introduction

2.0 Initial Turn-On

3.0 Measuring Frequency

4.0 WWVB Identification

5.0 Sample Frequency Error Calculations and Traces

6.0 Front Panel Controls and Indicators

7.0 Internal Switches

8.0 TM-500 Connector

9.0 Specifications

1.0 INTRODUCTION

This section describes how to use the Model 8163 to compare standard oscillator frequencies with the National Bureau of Standards WWVB signal. Accuracies of parts in 10^9 are easily obtained over a measurement time of a few hours. Accuracies of parts in 10^{11} are possible if the measurement time is extended to 8 to 24 hours.

2.0 INITIAL TURN-ON

After the receiver has been installed in the TM-500 Mainframe and the antenna installed and oriented, connect the antenna to the ANTENNA input connector on the front panel and turn the TM-500 power switch on. the green LOCK lamp will come on within one minute. If the red UNLOCK light stays lit, insufficient signal is being received probably due to improper antenna placing or alignment.

3.0 MEASURING FREQUENCY

Connect the local signal that you wish to calibrate to the LOCAL INPUT connector. Depress the FREQUENCY button corresponding to the input frequency being compared. The frequencies that may be compared are 0.1 MHz, 1.0 MHz, 5.0 MHz, and 10.0 MHz.

Changes in the phase relationship between the local input signal and the reference signal show up as meter movement. If the meter is perfectly constant, there is zero drift in the phase relationship and the local signal is exactly on frequency. The rate at which the meter moves measures the frequency error.

$$\text{FREQUENCY ERROR} = \frac{\triangle \text{ PHASE SHIFT}}{\triangle \text{TIME}}$$

For example, if it takes 50 seconds for the meter to deflect 50 microseconds (full scale), then the frequency error of the local signal is

$$\text{FREQUENCY ERROR} = \frac{50 \times 10^{-6} \text{sec}}{50 \text{ sec}}$$

$$= 1 \times 10^{-6}$$

If the meter deflects left to right, then the local input frequency is higher than the NBS reference. If the local input is lower than the reference, then the meter will deflect from right to left.

The scale may be changed from 50 microsecond full scale to 10 microsecond full scale by a switch inside the unit. Normally the switch is left in the 50 microsecond full scale position.

If you are adjusting your local oscillator, set it so the meter is not moving. The longer the phase drift is monitored, the greater precision of the calibration. For observations over periods of hours or days, a 0-1 ma chart recorder should be connected to the AUX OUTPUT. The Spectracom Model 8210 Chart Recorder or equivalent is recommended.

When the local frequency is in error by a large amount, the phase reading may be changing too rapidly for the meter to follow. In this case, the front panel AUX OUTPUT of the phase comparator may be viewed with an oscilloscope. Adjust your local oscillator so the frequency of this sawtooth signal is as low as possible, then use the meter when it is moving more slowly.

4.0 WWVB IDENTIFICATION

WWVB identifies itself by advancing its carrier phase 45^{o} at 10 minutes after every hour and returning the normal phase at 15 minutes after the hour. These phase changes will show up as meter deflection of 2 microseconds.

5.0 SAMPLE FREQUENCY ERROR CALCULATION AND SAMPLE TRACES

This section describes a frequency error calculation using a chart recorder connected to the AUX OUTPUT. Typical strip chart recordings that show the diurnal shift , a noisy day trace, and sun flares are discussed.

Figure 2-1 TRACE 1 shows that the frequency of the oscillator under test is high with respect to NBS. The frequency error is calculated below:

$$\text{FREQUENCY ERROR} = \frac{\Delta t}{T}$$

$$= \frac{11 \times 10^{-6} \text{ sec}}{3600 \text{ sec}}$$

$$= +3 \times 10^{-9}$$

This calculation may be made mentally by noting the phase drift in microseconds that occurs in one hour and dividing it by 3.6 to obtain the frequency error expressed in parts in 10^{9}.

Figure 2-2 TRACE 2 shows an oscillator which drifted low in frequency by almost 1×10^{-9} in a 9-hour period. Note the 2-microsecond phase shift that occurs once per hour. They identify the signal being received as WWVB.

Figure 2-3 TRACE 3 is a 24-hour trace showing the diurnal shift and some signal degradation during the night. After sunrise the trace shows the oscillator error to be only a few parts in 10^{-11}.

Figure 2-4 TRACE 4 illustrates overnight signal degradation and phase shift caused by sunset and sunrise. The diurnal phase shift will vary with geographic location and with time of year.

Figure 2-5 TRACE 5 shows a momentary unlock condition due to noise bursts, signal fading or poor antenna location. When receiver phase lock is re-established, the trace starts at a new position on the scale. Long-term measurement is not upset by this offset because the overall slope of the line is still easily determined.

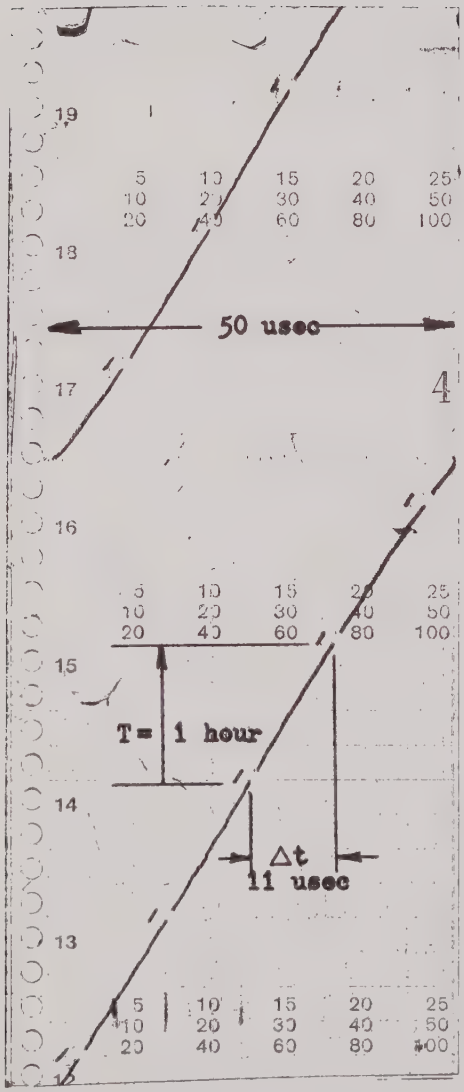


FIG. 2-1 An example of a frequency error calculation is made for the trace shown here. Oscillator error is positive (frequency is high) because the trace slopes to the right.

$$\text{Frequency Error} = \frac{\Delta t}{T} = \frac{11 \times 10^{-6} \text{ sec}}{3600 \text{ sec}}$$

$$= +3 \times 10^{-9}$$

This calculation may be made mentally to close approximation by noting the phase drift in microseconds (Δt) that occurs in one hour. Divide this by 3.6, yielding frequency error expressed as parts in 10^9.

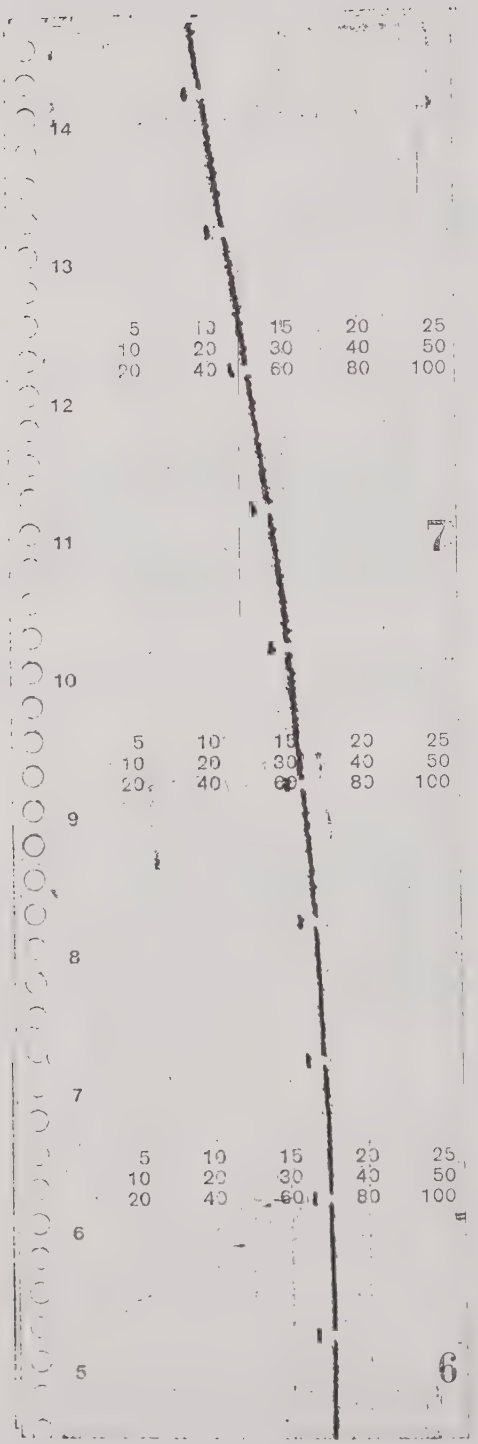


FIG. 2-2 TRACE 2 shows an oscillator which drifted low in frequency by almost 1×10^{-9} in a 9-hour period.

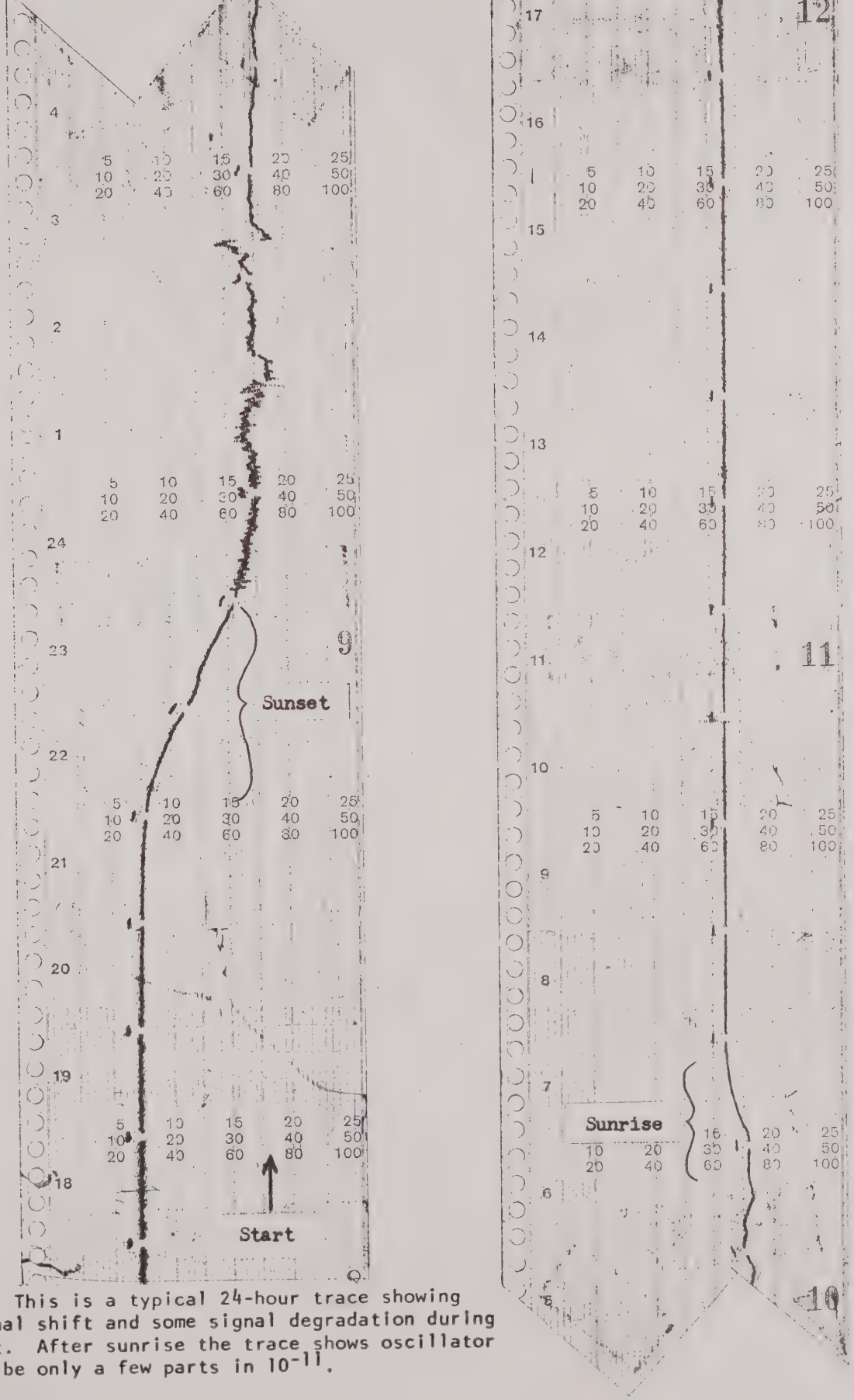


FIG. 2-3
TRACE 3 This is a typical 24-hour trace showing the diurnal shift and some signal degradation during the night. After sunrise the trace shows oscillator error to be only a few parts in 10^{-11}.

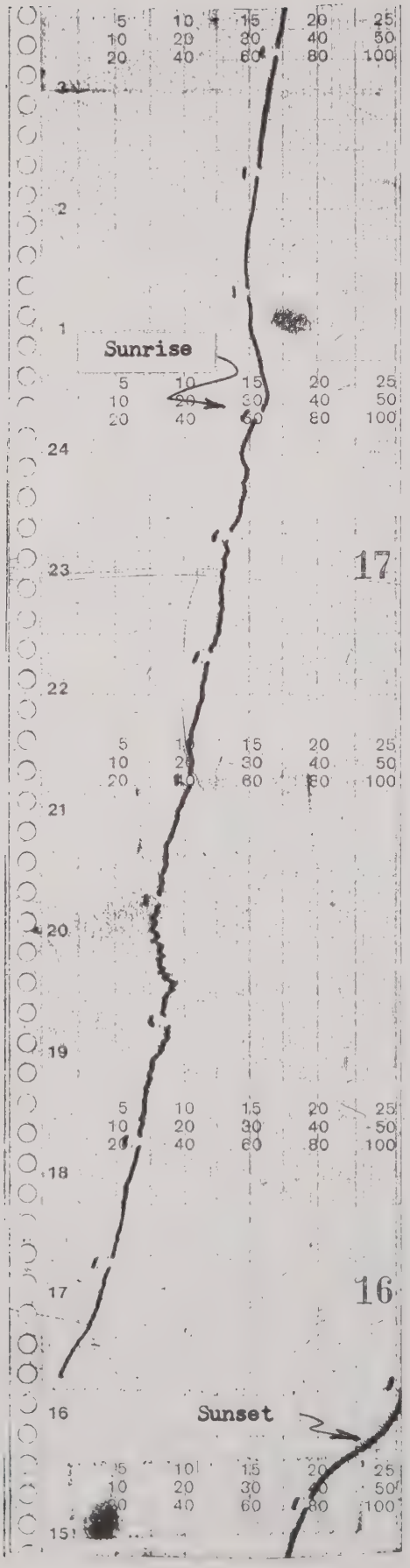


FIG. 2-4 TRACE 4 illustrates overnight signal degradation between sunset and sunrise. This effect will vary considerably with geographic location and with time of year, as well as with daily propagation variations.

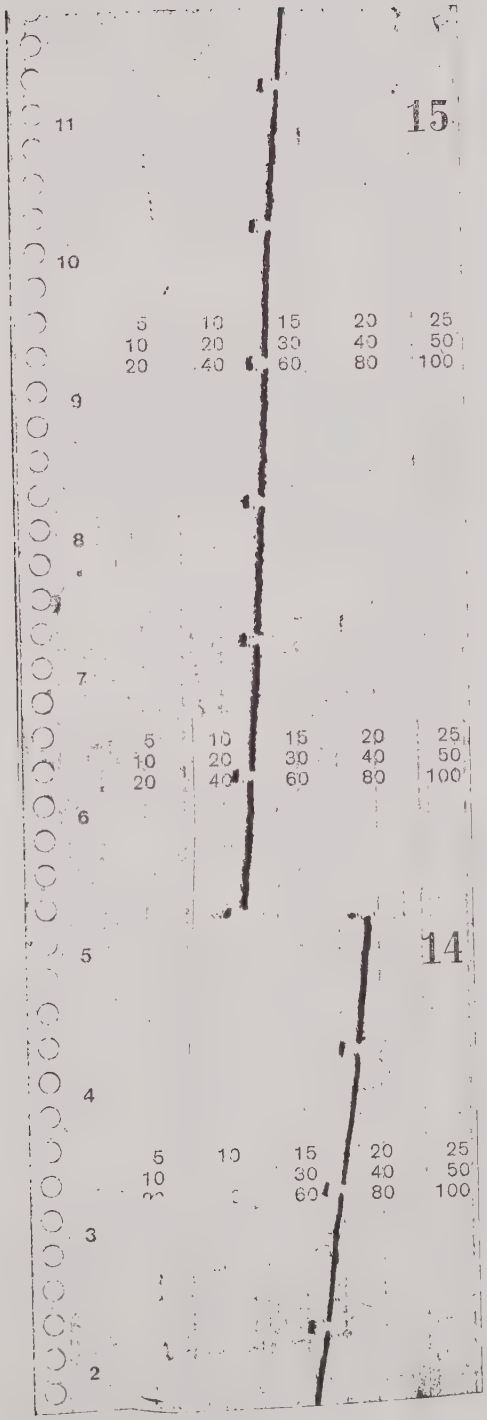


FIG. 2-5 TRACE 5 shows a momentary unlock condition due to noise bursts or signal fading. When receiver phase lock is re-established the trace starts at a new position on the scale.

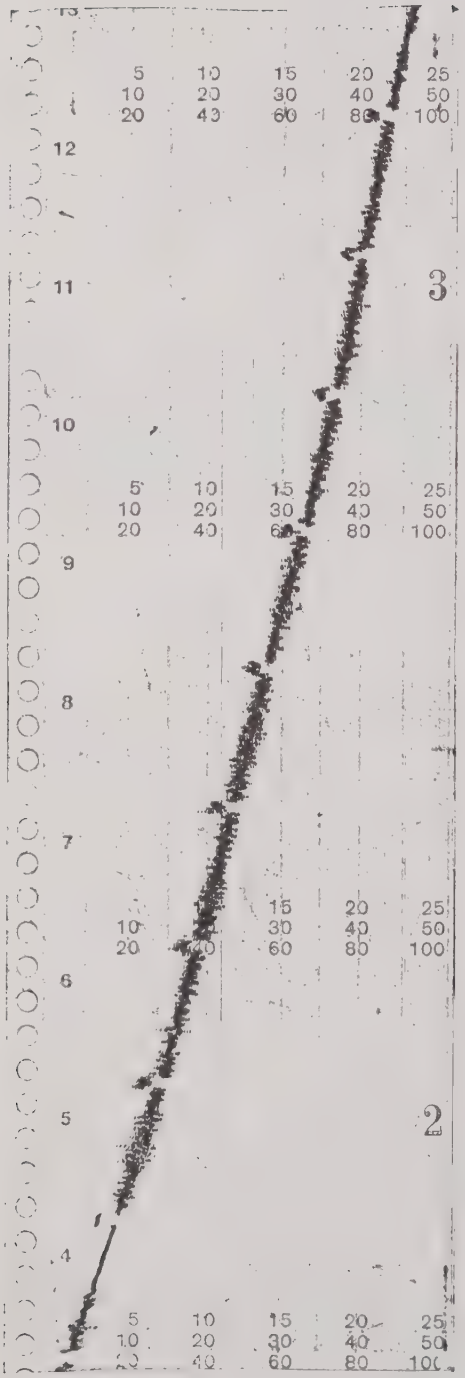


FIG. 2-6 TRACE 6 was made on a very noisy day, causing a trace width of about four microseconds. Both of the above problems are encountered less frequently with improved antenna placement.

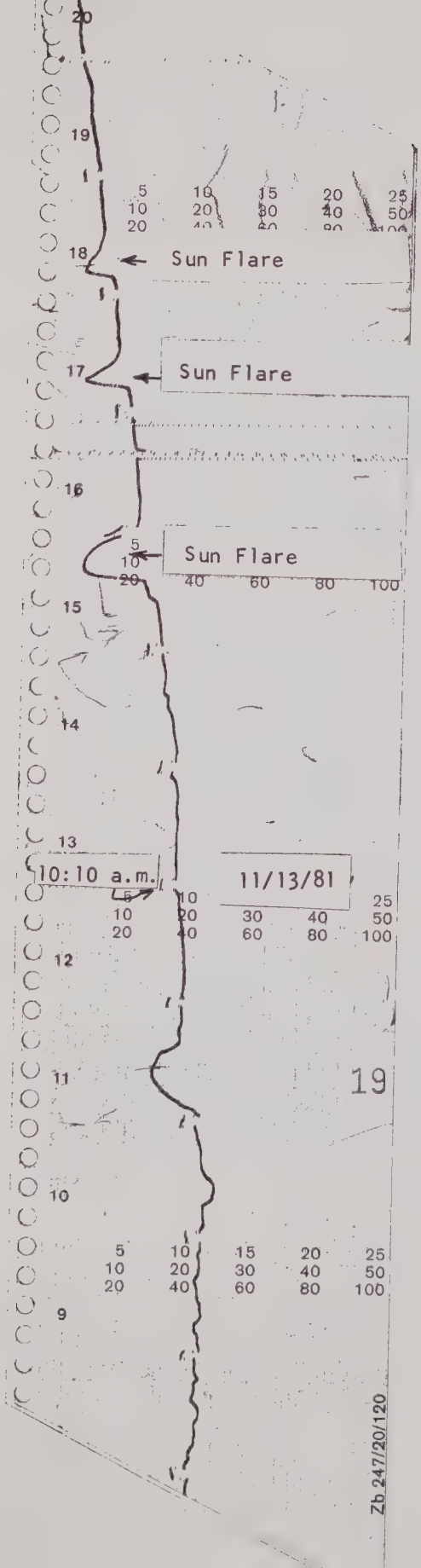


FIG. 2-7 TRACE 7 was made on a day with frequent sun flares.

Figure 2-6 TRACE 6 was made on a very noisy day, causing a trace width of about 4 microseconds.

Figure 2-7 TRACE 7 was made during an active sun flare period.

The ERROR CALCULATION CHART in Figure 2-8 can be used to find the frequency error as a function of phase change and time.

6.0 FRONT PANEL CONTROLS AND INDICATORS

Phase Comparison Meter: Normal readout is in microseconds of Relative Time, 0-10 or 0-50, selected by internal switch A2S1 (accessible after removing right side cover). For diagnostic purposes, the meter may be switched to read VCO lock voltage, by internal switch A2S2 (located below A2S1).

Antenna Connector: For use only with Model 8206 Loop Antenna or Model 8207 Antenna Preamplifier.

Aux Output: For use with external 0-1 ma chart recorder, for long term phase comparisons. Full scale calibration provided by internal control A2R80 (ground A2TP7, located above A2S2, while adjusting A2R80).

NBS Output Connector: Provides an output frequency, as selected by the Frequency push-buttons, phase locked to the NBS carrier.

Local Input: Phase Comparator input, 100 mV min., 10 V P-P max. Frequency should be that selected by the Frequency Push-buttons.

Lock/Unlock LED's: Indicate sufficient signal and proper phase lock to WWVB. NBS Output and Local Input should not be used when red UNLOCK LED is lit, as input signal is defective, or absent.

7.0 INTERNAL SWITCHES

There are three internal slide switches:

A/P Switch: This switch is located on the RF Amplifier board (the smaller of the two boards). If the switch is in the A (antenna) position, +12V is fed to the antenna through a 27K series limiting resistor. If the switch is in the P (preamplifier) position, +12V is fed out the antenna connector through a 5.6K series limiting resistor. The switch should be in the A position unless the Model 8207 Line Preamplifier is being used. The switch is set at the factory to A.

50/10 Switch: This switch is located on the Receiver board. In the 50 position the meter full scale deflection represents a 50-microsecond phase drift between the local input and WWVB. In the 10 position full scale deflection represents a 10 microsecond phase drift between the local input and WWVB. This switch also affects the full scale definition of the AUX OUTPUT. The switch is set at the factory to 50.

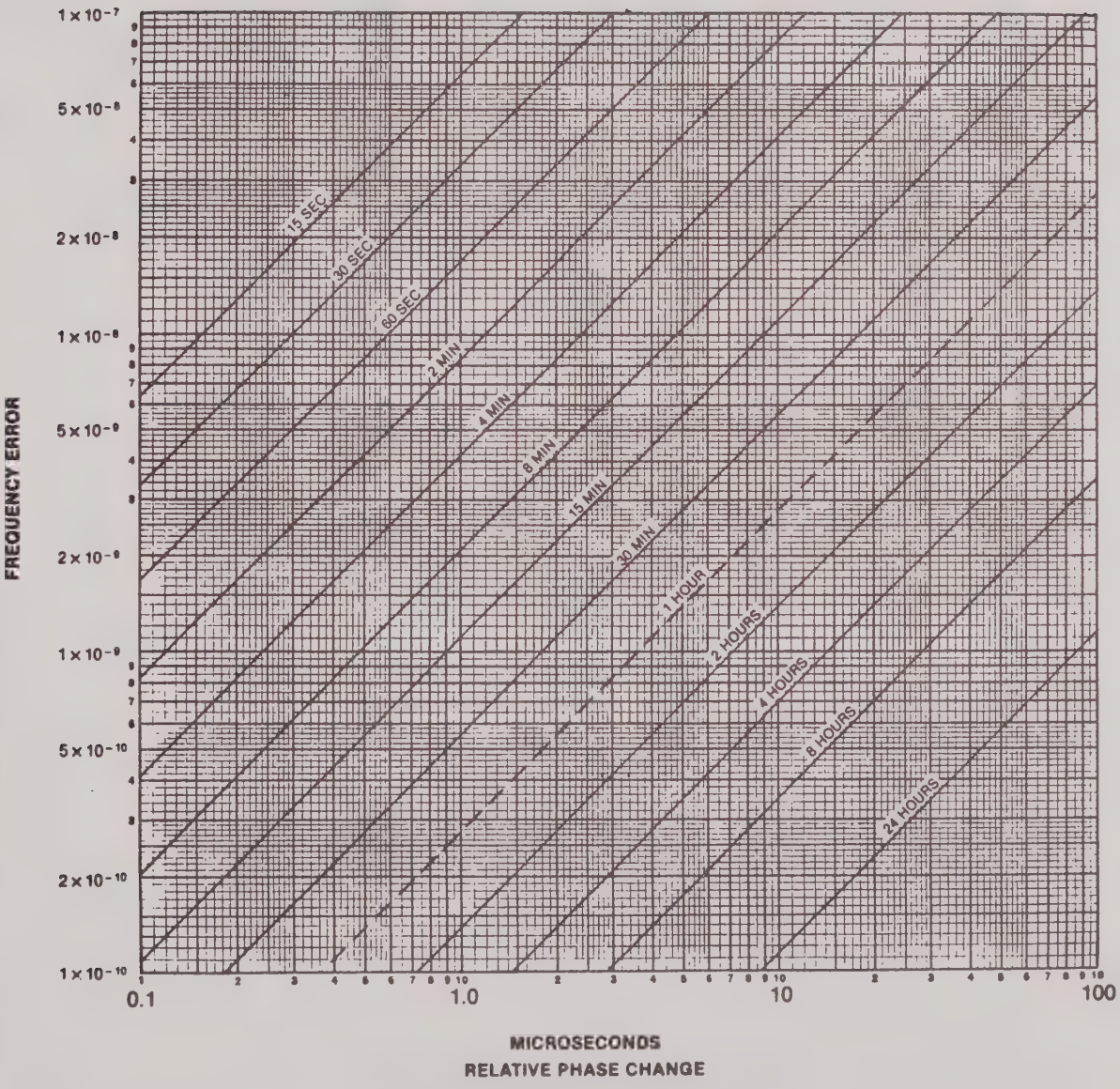


FIG. 2-8 ERROR CALCULATION CHART

V/Ø Switch: This switch is located on the Receiver board. In the V position the front panel meter displays VCO lock volts. In the Ø position it displays the relative phase difference in microseconds between the LOCAL INPUT and WWVB. The switch is set at the factory to Ø.

8.0 TM-500 CONNECTOR

Figure 2-9 shows the TM-500 connector as viewed from the front of the Mainframe. Signal names are listed next to their pin assignments.

	A	B	
Time Code Output (Optional)	28	28	Lock/Time Code GND
	27	27	Lock Output (Optional)
	26	26	
	25	25	
Chart Recorder Output 0-1 ma	24	24	
Chart Recorder GND	23	23	
Pad not used	22	22	Pad not used
	21	21	
	20	20	
	19	19	
Pad not used	18	18	Pad not used
1.0 MHz GND	17	17	
	16	16	
	15	15	Pad not used
1.0 MHz Output	14	14	GND
	13	13	
+33.5V DC	12	12	
Base MFQ1	11	11	Collector MFQ2
Emitter MFQ1	10	10	
	9	9	GND
-33.5V DC	8	8	
Emitter MFQ2	7	7	Collector MFQ1
Base MFQ2	6	6	
	5	5	
GND	4	4	GND
GND	3	3	GND
+11.5V DC	2	2	
	1	1	

NOTE: The board is keyed between pins 6 and 7 and 21 and 22.
MFQ 1 refers to Main Frame transistor Q1.

FIG. 2-9 TM-500 CONNECTOR PIN ASSIGNMENTS

9.0 SPECIFICATIONS

Received Standard Frequency: 60 KHz, NBS Station WWVB in Ft. Collins, Colorado.

Sensitivity: 0.4 uV rms into 50 ohms. Minimum field strength at Model 8206 Antenna, 30 uV per meter.

Phase Locked Outputs: 0.1, 1.0, 5.0, or 10.0 MHz, front panel selectable. TTL compatible (fan out, 2 max.) 3.4 V rectangular positive pulses into 93 ohms or greater resistive load or cable. Phase locked to WWVB carrier.

Phase Comparator: Front panel meter indicates phase changes of local input signal with respect to internal phase locked oscillator. Selectable scales of 50 usec and 10 usec relative time. Panel jack provides drive to external strip chart recorder with 0-1 ma movement.

Comparator Local Input: 0.1, 1.0, 5.0, 10.0 MHz, front panel selectable, 100 mV rms minimum into 1000 ohms.

Phase Lock Indication: Green panel lamp indicates phase lock. Red panel lamp indicates phase unlock due to antenna misdirection or disconnect, insufficient signal strength, etc.

Accuracy: 1×10^{-11}, as limited by the WWVB signal. Resolution limitations are avoided by using longer measurement times, so that the effects of atmospheric noise are minimized.

Model 8206 Loop Antenna: High gain directional ferrite loop in tubular housing 14½L x 2-3/4 Dia. (inches), 368L x 70 Dia. (mm). Built-in preamplifier receives its DC power over the coaxial cable center conductor from the receiver. Equivalent electrical height 5.0 cm.

Power Source: TM-500 Mainframe

Operating Temperature: 0 - 50°C.

SECTION 3

8163

OPTIONS AND ACCESSORIES

1.0 Option 05 - Time Code Output

2.0 Model 8206 Loop Antenna

3.0 Model 8211 Antenna Mount

4.0 Model 8207 Line Preamplifier - 60 KHz

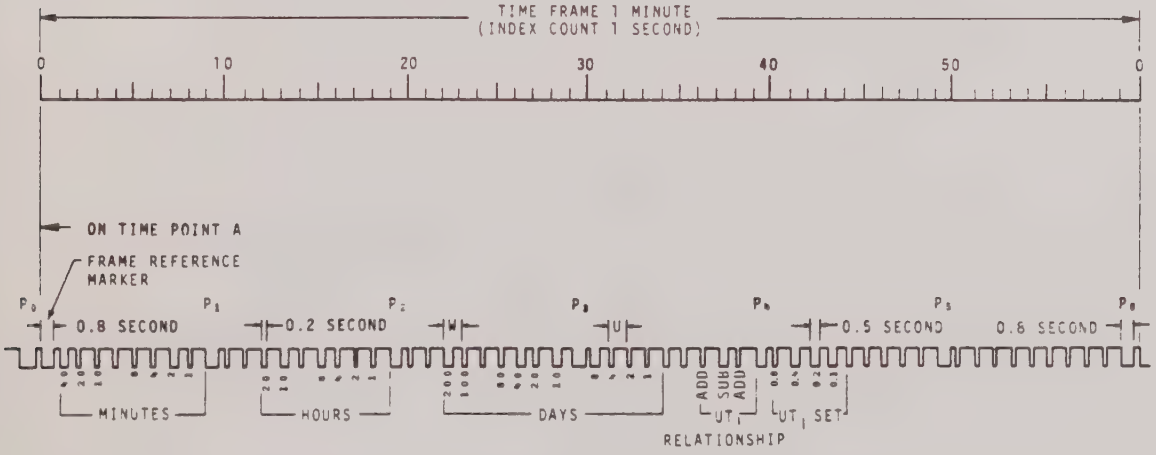
5.0 Model 8210 Chart Recorder

1.0 OPTION 05 - TIME CODE OUTPUT

Time code modulation is provided on the WWVB carrier for use in synchronizing accurate clocks and other timekeeping equipment. The modulation consists of once-per-second pulsed amplitude reductions of 10 dB, lasting either 200, 500, or 800 milliseconds. Decoding a one-minute data stream of this BCD time code yields date, time of day, and a correction factor for converting from atomic time (Coordinated Universal Time or UTC) to celestial time (UT1). (See Figure 3-1, TIME CODE FORMAT - OPTION 05.)

Atmospheric noise levels at 60 KHz are frequently very bad, and will cause false pulses to appear on the demodulated time code output. The noise levels are variable, depending on factors such as season, time of day and geographical location. Noise is lower in the northern latitudes during winter daytime hours, and higher at night during the summer in southern latitudes. In U. S. coastal areas for example, where the WWVB signal strength is nominally 100 microvolts per meter, the signal-to-noise ratio may be as bad as -23 dB in a 1 KHz bandwidth. The Spectracom receiver, due to its unique synchronous detector with extremely narrow bandwidth will stay phase locked to the WWVB carrier with signal-to-noise ratios as poor as -35 dB. Time code errors will occur on bad days, and error detection techniques are necessary if the output data is to be useful.

The 10 dB reduction of the WWVB carrier is inverted in the demodulation process and appears at the output as a positive-going TTL-compatible pulse with a fan out of 2. With Option 05 the signal is available at pin 28A of the rear edge connector P1 on the A2 Receiver Assembly.



BINARY CODED DECIMAL TIME-OF-YEAR CODE WORD (23 DIGITS)
CONTROL FUNCTIONS (15 DIGITS) USED FOR UT1 CORRECTIONS
6 PPM POSITION IDENTIFIER MARKERS AND PULSES (P_0 THRU P_6)
(REDUCED CARRIER 0.8 SECOND DURATION PLUS 0.2 SECOND DURATION PULSE)
W - WEIGHTED CODE DIGIT (CARRIER RESTORED IN 0.5 SECOND - BINARY ONE)
U - UNWEIGHTED CODE DIGIT (CARRIER RESTORED IN 0.2 SECOND - BINARY ZERO)

UTC AT POINT A	UT1 AT POINT A
258 DAYS	258 DAYS
18 HOURS	18 HOURS
42 MINUTES	41 MINUTES
	59.3 SECONDS

NOTE: BEGINNING OF PULSE IS REPRESENTED BY NEGATIVE-GOING EDGE.

FIG. 3-1 WWVB TIME CODE FORMAT - OPTION 05

2.0 MODEL 8206 LOOP ANTENNA

Figure 3-2 shows the Model 8206 Loop Antenna mounted on the Model 8211 Antenna Mount.

The Model 8206 is a high gain directional ferrite loop antenna housed in a tubular housing 14½L x 2-3/4 Dia. (inches). It contains a built-in preamplifier which receives its DC power from the receiver over the coaxial cable center conductor. The antenna equivalent electrical height is 5.0 cm.

3.0 MODEL 8211 ANTENNA MOUNT

The Model 8211 Antenna Mount consists of two 2' sections of 1" PVC pipe with male and female adapters. The base contains a mounting flange and two cross members. If the antenna to PVC pipe connection is tight, spray both pieces with a silicon lubricant. If only one of the 2-foot mast sections is used, the center of gravity will be lower, thus improving the mounting stability.

4.0 MODEL 8207 LINE PREAMPLIFIER - 60 KHZ

The Spectracom Model 8207 Preamplifier is a low noise, tuned, 60 KHz line amplifier used in the antenna feed line wherever the WWVB signal strength is less than 50 uV/meter at the Model 8206 Loop Antenna or less than 0.3 uV at the receiver antenna terminal. Typical locations where the Preamplifier is probably required are Hawaii, Alaska, Puerto Rico, and the Canal Zone. The Model 8207 Preamplifier provides approximately 40 dB of gain between the antenna and receiver, increasing sensitivity to 3.0 nanovolts.

The Preamplifier is connected in the antenna feed line with input connected to the antenna and output connected to the receiver. Because of the high gain of the system, it is recommended that the preamplifier be located at least 10 feet away from the receiver, perhaps where the antenna line enters the room where the receiver is located. The antenna must be at least 25 feet beyond the Preamplifier from the Receiver. Switch A1S1 of the receiver RF Amplifier must be set at its right-hand position, marked PREAMP or P, prior to equipment turn-on, to apply DC voltage to the Model 8207 on the antenna feed line. If the preamplifier is removed from the system, the switch must be placed in the left-hand position, marked ANT or A prior to turn-on.

It is strongly recommended that no internal adjustment of the Preamplifier be made without consulting the factory.

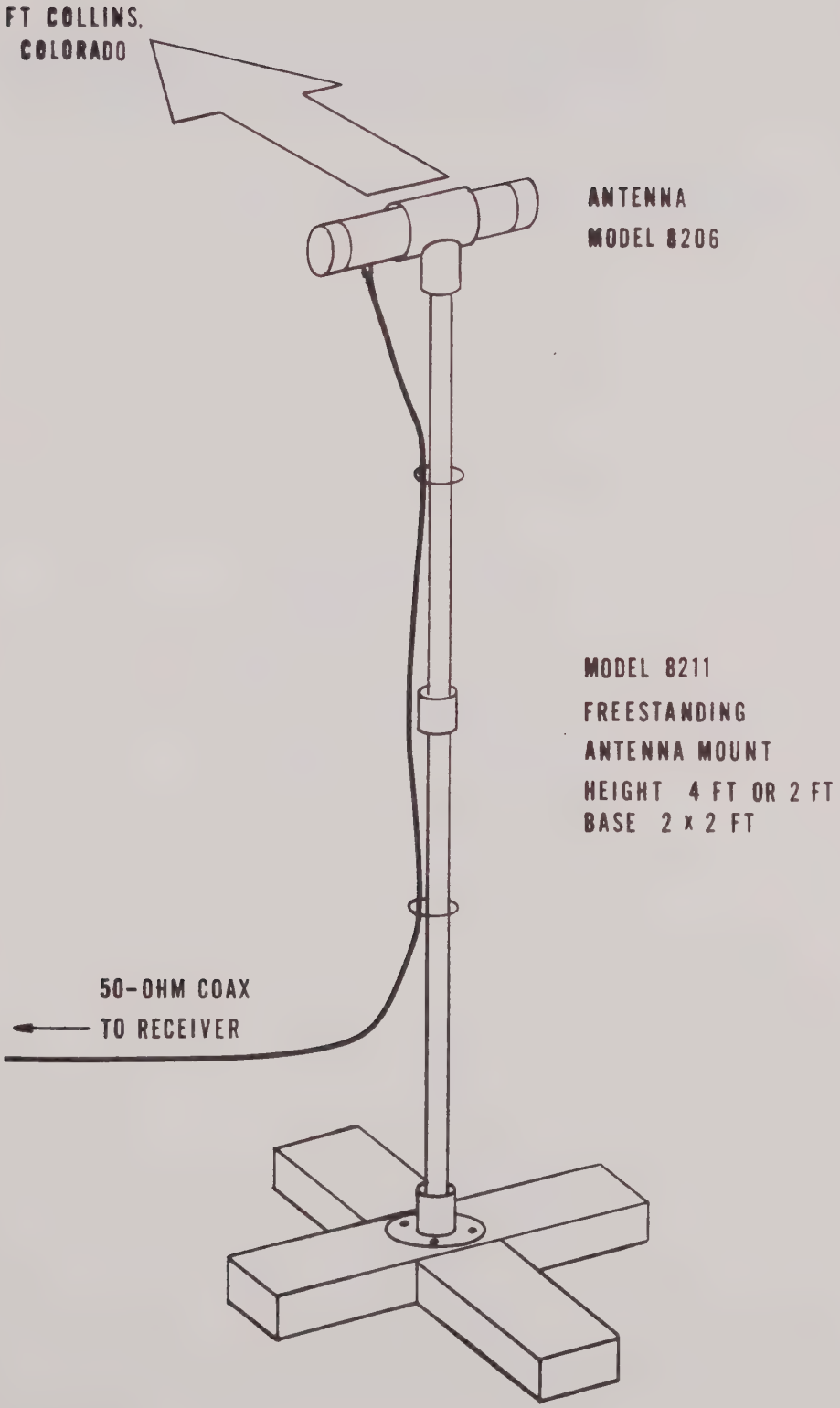


FIG. 3-2
ANTENNA MOUNT MODEL 8211

5.0 MODEL 8210 CHART RECORDER

The Model 8210 Chart Recorder is a 0-1 milliampere low-speed strip chart recorder which provides a recording by making sequential impressions on a pressure-sensitive chart paper. The chart speed is 1 inch/hour. One roll of chart paper will last a month. The part number for the chart paper is MP00024.

The unit operates on 100-135 volts AC, 60 Hz power. The overall dim dimensions are 3-5/8W x 5-5/8H x 5-3/8D (inches).

SECTION 4

8163

PRINCIPLES OF OPERATION

1.0 Introduction

2.0 Block Diagram

3.0 Signal Strength Measurement

4.0 RF Amplifier A1, P/N 001100

5.0 Receiver Assembly A2, P/N 008200

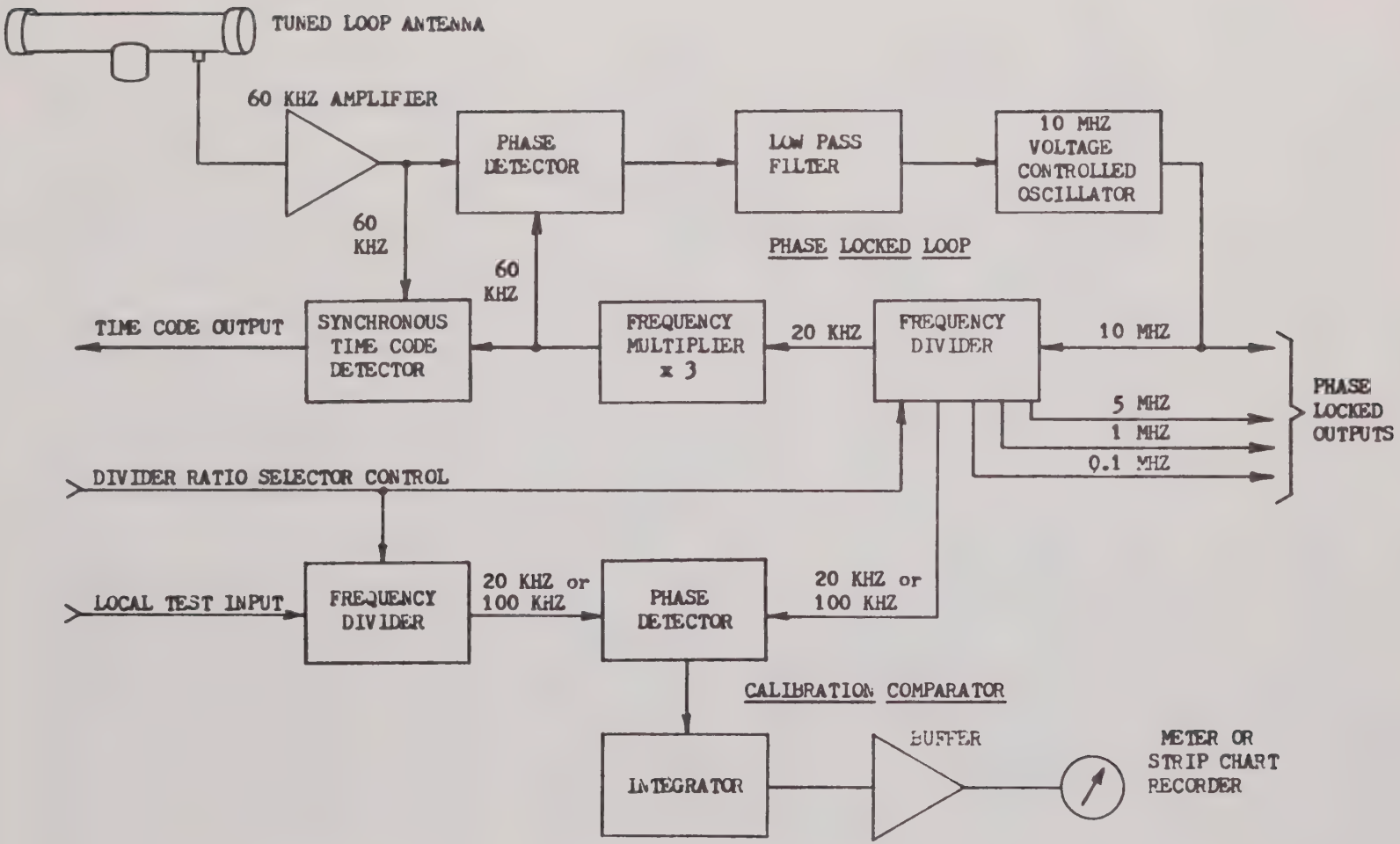


FIG. 4-1 SPECTRACOM WWVB RECEIVER BLOCK DIAGRAM

3.0 SIGNAL STRENGTH MEASUREMENT

The receiver may be used to measure relative field strength of the 60 KHz signal. This measurement may be used to optimize the location and orientation of the antenna.

The WWVB receiver employs synchronous AGC which responds to the 60 KHz signal only and is not affected by noise. The AGC level is an indication of signal strength.

To measure the AGC voltage, open the cover of the receiver and find test points TP3 and TP6 on the A2 Receiver board. Place the negative lead of a high impedance DC voltmeter on TP3 (orange) and the positive lead on TP6 (blue).

In a field strength of 100 microvolts/meter, this AGC voltage will be about +2.0 vdc when using a properly oriented Model 8206 Antenna. The AGC voltage will be higher in stronger signal locations, rising to a limiting value of +3.0 volts or more as front end input voltage climbs above 100 microvolts.

As the signal strength decreases to the receiver's phase lock threshold of about 0.2 microvolts, the AGC voltage will decrease to about +1.0 vdc. Below that level, the red UNLOCK panel indicator will come on. If the input signal is removed completely, the AGC voltage will decrease to a varying level around zero. As signal is reapplied and increased, the receiver will again lock at an AGC level of about +1.0 volt.

To use the AGC voltage to aid antenna orientation, place the antenna so that AGC voltage is maximized. The circuit that produces the AGC voltage has a very long time constant, so a pause of 30 to 60 seconds is necessary after each move of the antenna to allow the AGC to stabilize at its new level.

A few minutes of experimentation should produce good antenna orientation. The following tips will help:

1. The antenna must be at least 25 feet away from the receiver. If it is not, the antenna will get signals from the receiver as well as from WWVB, and results will be poor. If the receiver and antenna are too close together, the receiver can actually lock to itself.

2. Aim the antenna broadside to the transmitter, as shown in Section 1, and KEEP IT AT LEAST 2 FEET FROM ANY METAL. If the antenna is resting on a metal window sill, a metal shelf, or metal roof decking, it will be detuned and poor reception will result.

3. If the antenna is dropped, the ferrite core can crack and severely detune the antenna. HANDLE WITH CARE, and install in a location where it won't fall or be knocked down.

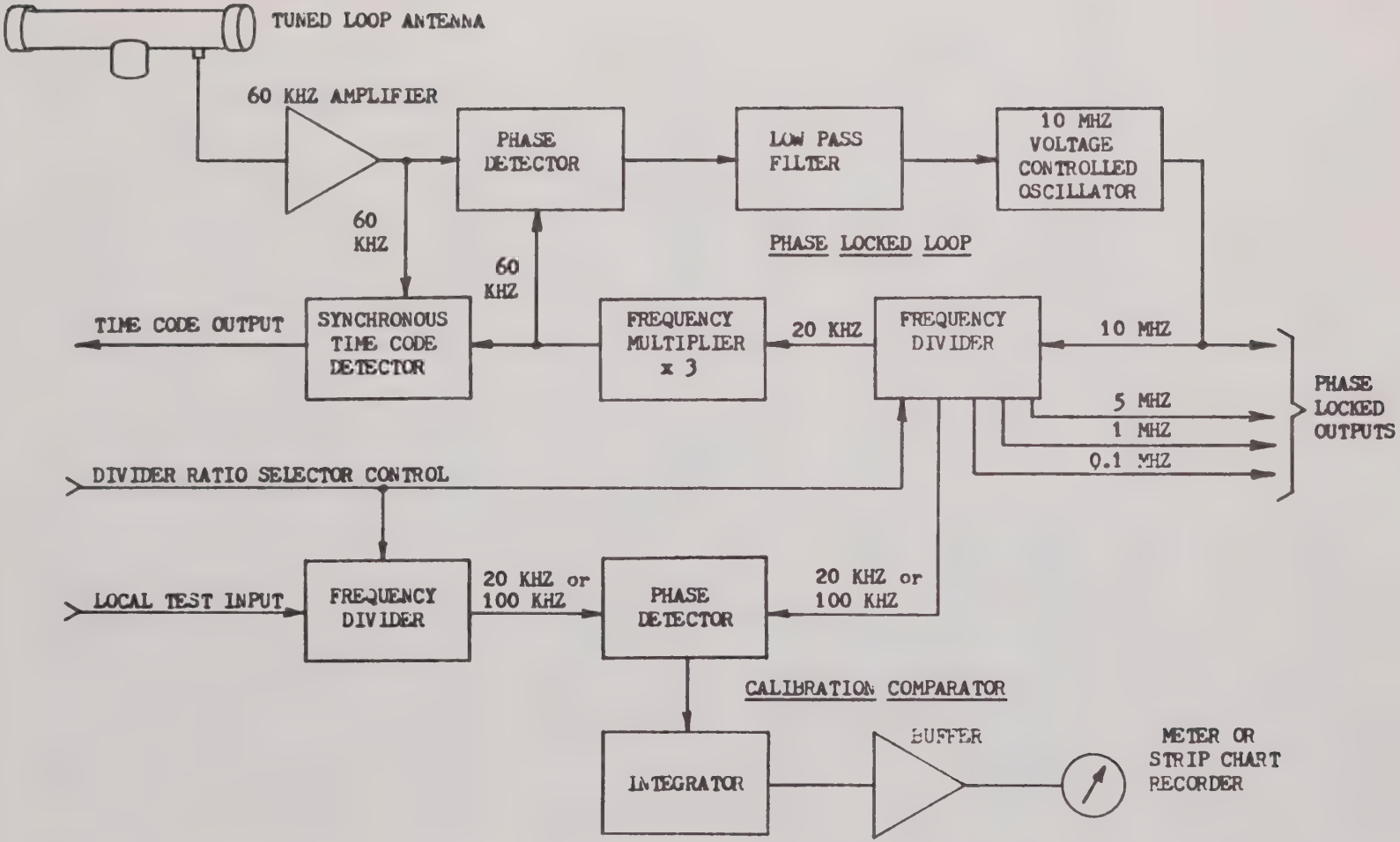


FIG. 4-1 SPECTRACOM WWVB RECEIVER BLOCK DIAGRAM

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1. The antenna must be at least 25 feet away from the receiver. If it is not, the antenna will get signals from the receiver as well as from WWVB, and results will be poor. If the receiver and antenna are too close together, the receiver can actually lock to itself.

2. Aim the antenna broadside to the transmitter, as shown in Section 1, and KEEP IT AT LEAST 2 FEET FROM ANY METAL. If the antenna is resting on a metal window sill, a metal shelf, or metal roof decking, it will be detuned and poor reception will result.

3. If the antenna is dropped, the ferrite core can crack and severely detune the antenna. HANDLE WITH CARE, and install in a location where it won't fall or be knocked down.

4. If the antenna is placed inside a building that has steel structural members or a metal roof, the WWVB signal will be attenuated, and poor reception may result. Noise being generated inside the building may also interfere with good reception. For these reasons we recommend installing the antenna outdoors above the roof where there is a clear line of sight toward the transmitter. Here, the metal frame of the building helps shield internal building noise from the antenna.

4.0 RF AMPLIFIER, A1, P/N 001100

The RF Amplifier assembly filters and amplifies the antenna signal to a level suitable for use by the A2 Receiver Assembly. Figure 4-2 is the schematic for the RF Amplifier. Figure 4-3 is the Assembly Drawing.

The signal from the antenna is applied to input transformer T1 which matches the 50-ohm input impedance to the input of the first stage of amplification, Q1. The impedance looking into transformer T1 is approximately 50 ohms, with the secondary of T1 and capacitor C2 forming a 60 KHz tuned circuit with approximately a 200 Hz bandwidth. The output of amplifier Q1 is applied to transistor Q2 which, together with crystal Y1 and capacitors C7, C8, C9 and C10, form a narrow bandpass crystal filter centered at 60 KHz. The filter bandwidth is approximately 30 Hz, with capacitor C8 trimming the bandpass center frequency at 60 KHz. Capacitors C9 and C10 feed to the output side of the crystal a signal that is 180^{o} out of phase and is tuned so that a passband null occurs at 100 KHz. This combination provides a sharp bandpass response at 60 KHz with very steep high frequency rejection.

The output from the crystal filter is fed to amplifier U1, whose output is tuned with inductor L3 and capacitors C14, C15, and C23. Amplifier U1 is the stage that provides AGC for the receiver, with its gain control input port at pin 5. Trimmer resistor R19 provides AGC level adjustment.

The output of amplifier stage U1 is fed to the input of the second amplifier stage U2, the output of which goes to emitter follower Q3, providing the output signal to the A2 Receiver assembly.

The supply voltage for the RF amplifier is +12 volts fed in at P2-1 and through R18, L2, and L1, to provide power for the amplifier stages. This power supply is also fed through switch S1 and resistor R2 to the input transformer where it goes out onto the antenna line to provide DC voltage to the preamplifier in the antenna. If switch S1 is moved to the P (preamplifier) from the A (antenna) position the power supply is fed through R1 providing a smaller voltage drop so that both a series line preamplifier Model 8207, and the antenna may be powered from the receiver.

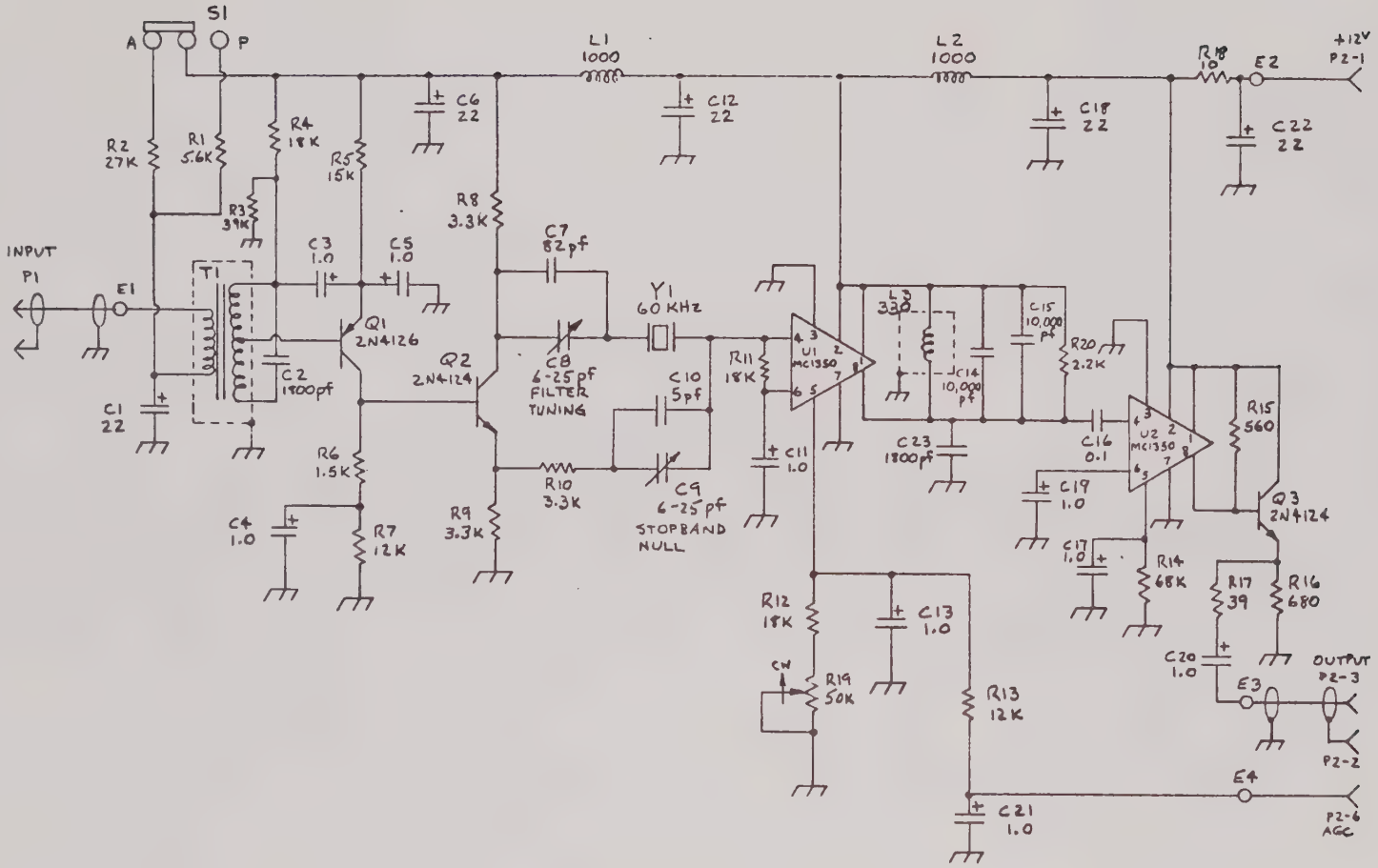

FIG. 4-2 RF AMPLIFIER, A1, SCHEMATIC

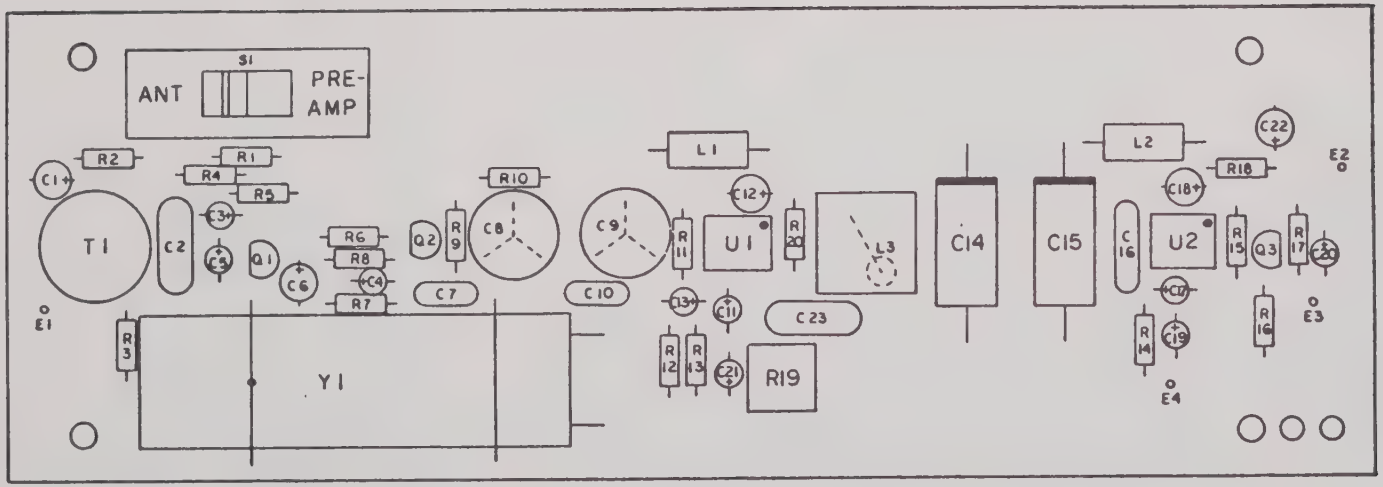

FIG. 4-3 RF AMPLIFIER, A1, ASSEMBLY DRAWING

5.0 RECEIVER ASSEMBLY, A2, P/N 008200

Figures 4-4, 4-5, and 4-6 show the schematic for the Receiver board. Figure 4-7 is the Assembly Drawing.

When the signal from the RF amplifier assembly is fed into connector J1-3, it splits and goes in two directions. The first, through U1 and U2A, is the phase locked loop which provides synchronous detection of the carrier frequency and translates it to 10 MHz at the detector output. The second is through U3 and U2B to provide AGC voltage, time code detection, and phase lock/unlock indication.

Other functions of the A2 receiver assembly board include:

1. Derivation of front panel NBS Output signal from the 10 MHz phase locked oscillator.

2. Buffering, amplifying and dividing the external local oscillator input to the front panel and feeding it to the phase comparator.

3. The phase comparator which compares the local input frequency with the phase locked oscillator output to determine frequency error and drift.

4. Power supplies.

5.1 Phase Locked Loop

The reference input to phase detector U1 pin 1 comes from the RF amplifier output (A1 assembly). The comparison frequency input to phase detector U1 pin 8 is derived from the phase locked oscillator. The output from U1 is a DC voltage which is a function of the phase difference of these 60 KHz signals. The output is amplified by U2A, the loop filter/amplifier. This amplified DC voltage is then fed through amplifiers Q2 and Q3 where it becomes the VCO control voltage which pulls the oscillator (Q4 and Y1) into phase lock relationship with the incoming carrier frequency from WWVB. This oscillator pulling is performed by the DC voltage which appears on the upper end of voltage variable capacitor CR2 controlling the "pulling" of crystal Y1. The oscillator output frequency is thus held exactly to 10 MHz by the DC voltage applied to the VCO control line. The collector output from Q4 at BB is buffered by gate U5A and fed to a divider chain consisting of U8, U9, U10, and U16. At various points within this divider chain frequencies are picked off and fed to the NBS output connector at the front panel through gate U6B. NBS output frequency is chosen by the front panel push button selector switches through gates U7A, U7B, U7C and U7D. This phase locked signal is divided down to 100 KHz and to 20 KHz. These frequencies are buffered by U18A, U18D and U18B which feed switch S1.

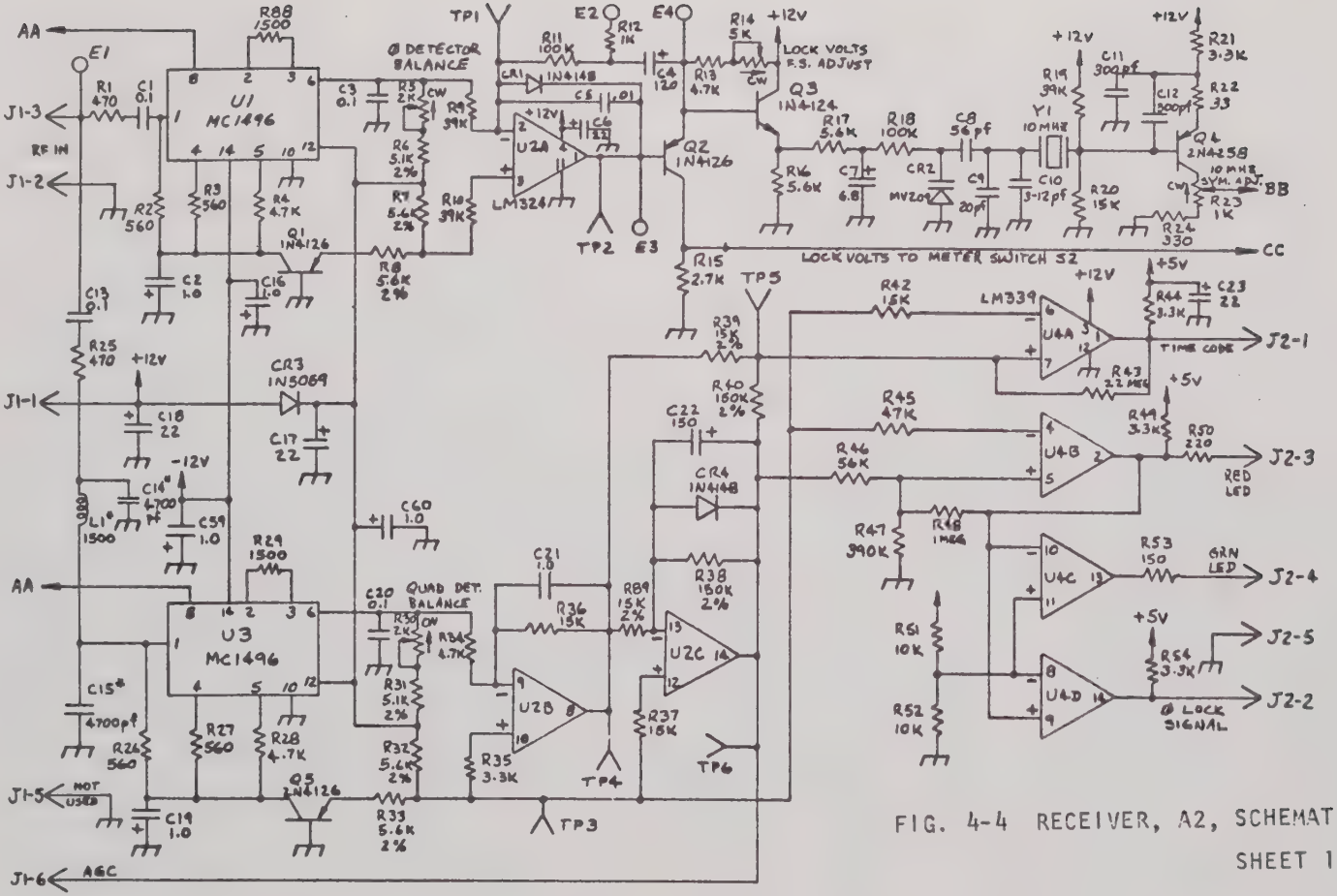

FIG. 4-4 RECEIVER, A2, SCHEMATIC
SHEET 1

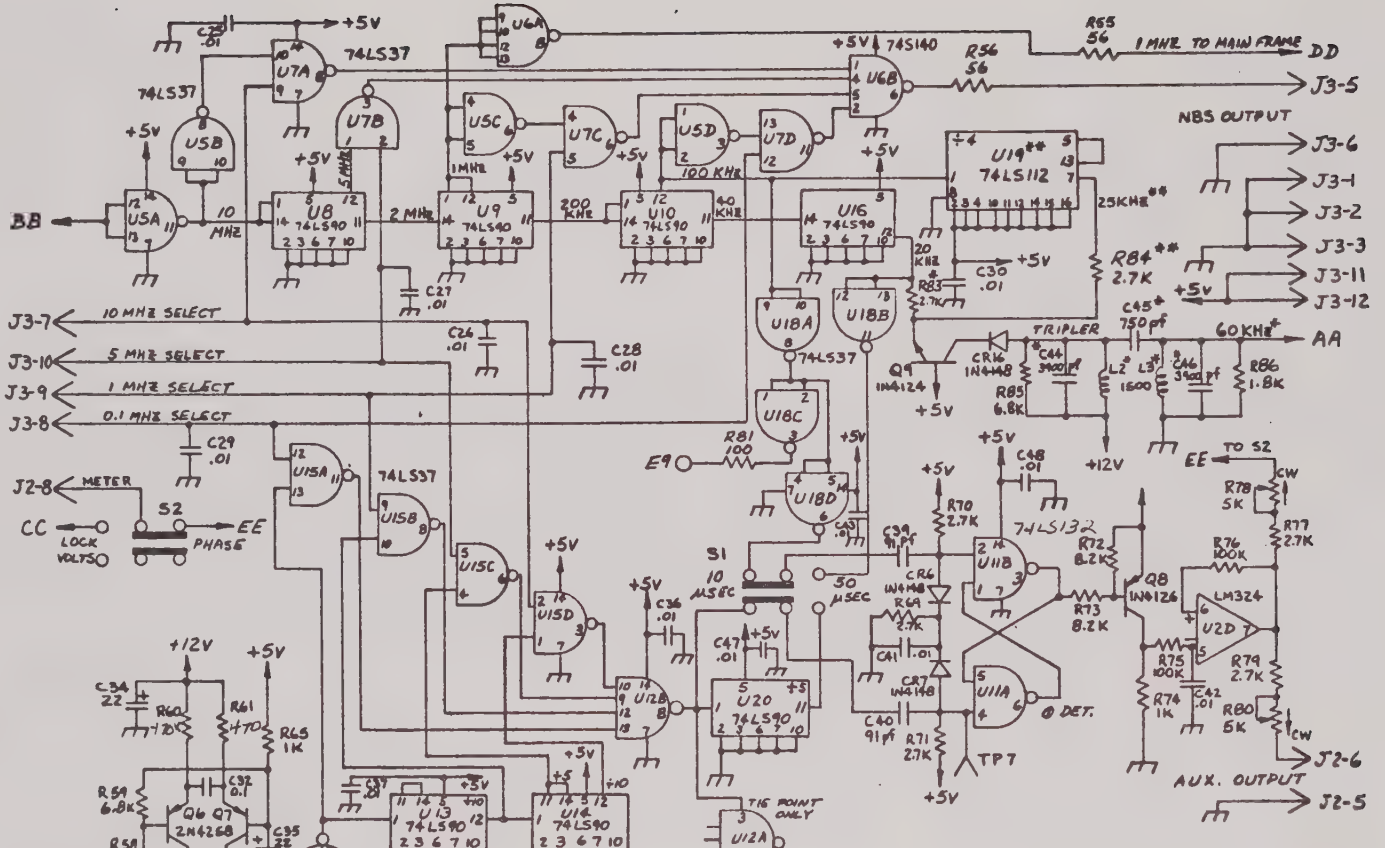

FIG. 4-5 RECEIVER, A2, SCHEMATIC

SHEET 2

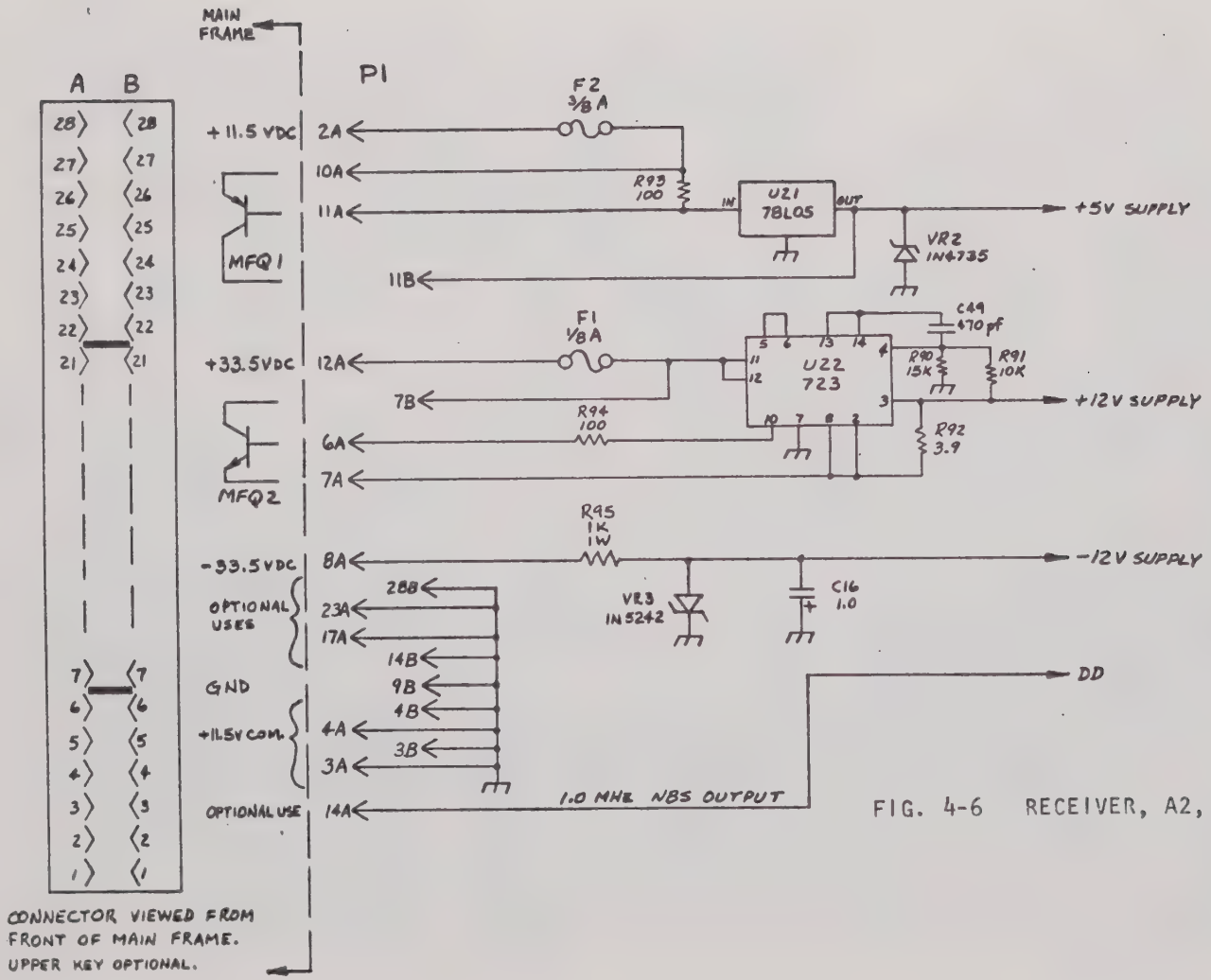

FIG. 4-6 RECEIVER, A2, SCHEMATIC SHEET 3

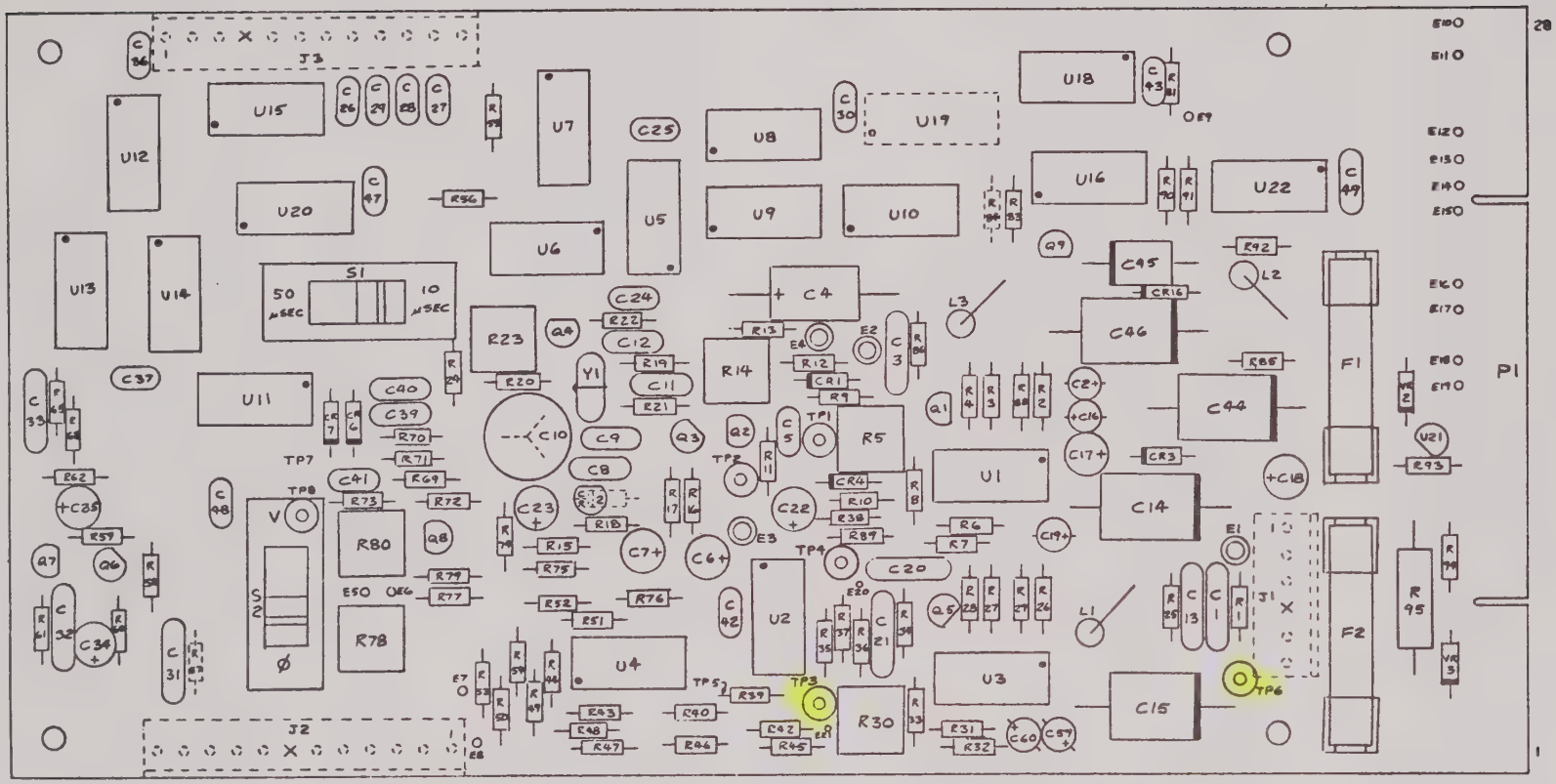

FIG. 4-7 RECEIVER, A2, ASSEMBLY DRAWING

The 20 KHz output from U16 is fed to the tripler stage Q9 where the output at 60 KHz is filtered and fed back at point AA into the comparison input of phase detector U1, pin 8. Thus, the phase locked loop translates the incoming 60 KHz carrier frequency from WWVB to 10 MHz at the crystal oscillator output, and divides it down to 60 KHz for comparison in the phase detector.

5.2 AGC Loop

The input from the RF amplifier also goes to pin 1 of phase detector U3 after being shifted in phase by 90° by C14, C15, and L1. Thus, U3 becomes a quadrature phase detector whose output at pin 6 goes high only when the inputs at pin 1 and pin 8 are in quadrature with each other at 60 KHz. The output level from this phase detector is proportional to the level of the incoming carrier, and thus provides the basis for time code amplitude detection, and for AGC voltage generation.

The phase detector output is amplified by U2B, whose time constant is approximately 15 milliseconds. The output of U2B is split and is fed in two directions: first through R39 to voltage comparator U4A where small amplitude variations in the signal are detected and provide the time code output. Time code output is provided as Option 05 and is not present in all receivers.

The output of U2B is fed through R89 to amplifier U2C which has an integrating time constant of approximately 25 seconds. The slowly varying output of U2C is used as the AGC voltage and is fed back to the RF amplifier to control the gain of the input stage.

Because the AGC voltage is derived from the output of a quadrature detector, it is present only after phase lock is achieved, and thus becomes the basis for a synchronous AGC. The gain of the amplifier in the front end of the receiver is running wide open until phase lock occurs. After phase lock is acquired the input amplifier gain is reduced to a level just sufficient to provide a reference for the phase locked loop and other stages in the A2 receiver assembly. Thus, no stages in the A2 receiver assembly are allowed to saturate or be overdriven in strong signal conditions.

Test point 3 is located at the reference voltage against which AGC amplifier U2C operates. Thus, the voltage measured from TP3 to TP6 is proportional to the input signal level and can be used as an indication of signal strength. If the antenna is adjusted and aimed to maximize this AGC voltage, optimum receiver operation is obtained.

The AGC voltage is also sent to voltage comparators U4B, U4C, and U4D as a means of indicating phase lock. When the AGC voltage measured between test points 3 and 6 rises to approximately 1.0 volt DC, the output of comparator U4B goes high turning off the red UNLOCK panel indicator on the front panel. When lock is acquired, the green light goes on. The output of U4D goes high and provides an output at J2-2 showing that phase lock has been acquired. This can be connected to pin 27B on the rear connector to provide a remote indication of phase lock.

5.3 Phase Detector Balance Adjustments

The output of phase detector U1 for the phase locked loop control is balanced by adjustment of trimmer potentiometer R5. The output of the quadrature phase detector U3 is balanced by adjustment of trimmer potentiometer R30.

5.4 Phase Comparator

When local oscillators to be calibrated are fed into the local input jack on the front panel they appear at J2 pin 11. The buffer amplifier Q6-Q7 feeds this signal to gate U11D where it is then divided in frequency by U13 and U14. Gates U15A, U15B, U15C and U15D are used to select the appropriate divider output to provide a 100 KHz signal to S1 and divider U20.

If the phase comparator selector switch, S1, is placed in the 50 position then the inputs to the phase detector U11B and U11A will be 20 KHz derived from the NBS received signal and 20 KHz from the signal being measured. The phase detector output will cause the meter to read 50 microseconds full scale.

If the phase comparator selector switch, S1, is placed in the 10 position then the inputs to the phase detector will be 100 KHz derived from the NBS signal and 100 KHz derived from the signal being measured. The phase detector output will cause the meter to read 10 microseconds full scale.

U11A and U11B are connected as a flip-flop phase detector whose output pulse width is proportional to the relative phase relationship between the two input signal pulses. Buffering of this output pulse is provided by Q8, and integration of the output pulse by R75 and C42. Buffer amplifier U2D then drives the front panel meter and the AUX OUTPUT for an external meter or chart recorder. Full scale adjustments of both are made by adjusting the current to ground through a milliammeter at each output to exactly 1.0 mA with no local signal input and with TP7 grounded, causing the phase detector to indicate full scale. Trimmer resistor R80 adjusts full scale setting of AUX OUTPUT and R78 is used to adjust the front panel full scale meter reading.

5.5 Power Supplies

The power supply is shown in Figure 4-6. The +5V is provided by voltage regulator U21, PNP transistor MFQ1 located in the TM-500 Mainframe and Zener diode VR2. A 3/8A AGC located on the A2 board fuses the input side of the regulator.

The +12 volts is provided by voltage regulator U22 and NPN transistor MFQ2. Fuse F1, 1/8A AGC, is in series with the input to the regulator.

The -12 volts is provided by series resistor R95 and Zener diode VR3.

SECTION 5

8163

MAINTENANCE

1.0 Introduction

2.0 Calibration

3.0 Test Equipment

4.0 Test Set-Up

5.0 Test Procedure

6.0 Model 8207 Antenna Preamp Alignment

1.0 INTRODUCTION

This section describes the calibration, alignment and testing of the Model 8163.

2.0 CALIBRATION OF WWVB RECEIVERS

Periodic calibration of a WWVB receiver, in the usual sense that an instrument must be sent to the Bureau of Standards or calibrated against a traceable standard, is unnecessary. Time and frequency are the only two measurable quantities that can be transmitted via a radio signal. Because of this, it is possible to be "connected" directly to the Bureau of Standards via a radio signal for calibration of both time and frequency.

We can draw a simple analogy by considering a secondary voltage standard, or standard cell, which is used for voltage calibration. Standard cells are usually returned to the Bureau of Standards or a secondary standards laboratory where they are calibrated and certified traceable to the Bureau of Standards. If it were possible to have a pair of wires connected from your laboratory directly to the "standard volt" at the Bureau of Standards, it would be unnecessary to return your voltage cell periodically to the Bureau of Standards for calibration. This is exactly the situation that we find with time and frequency being received by a radio signal directly from the Bureau of Standards. Periodic "calibration" of the instrument is unnecessary because its output is being derived directly from the Bureau of Standards. The only periodic checks that are necessary are ones to determine that the receiver is operating properly and that the correct signal is being received.

The procedure for verifying proper equipment operation is described below.

1. Check to see that the green lock light is lit on the front panel of the receiver. This establishes that the receiver is phase locked to a 60 KHz signal being received via the antenna.

   LOCK LAMP ON _____

2. Check to see that the hourly offset of approximately 2.1 microseconds is occurring at 10 minutes after the hour. These offsets occur due to the 45^{o} phase shift that is applied to the signal at the transmitter at 10 minutes after the hour, returning to normal 15 minutes after the hour. The presence of those offsets both identifies the station and gives hourly "time ticks" on a chart recorder trace of the phase comparator output. Their presence indicates that the chart recorder line can be coming only from the National Bureau of Standards.

   OFFSET (PHASE SHIFT) of
   2.1 usec at 10 and 15
   minutes after each hour_____

3. Move the V/Ø lock voltage switch on the A2 board to the "lock voltage" position, V, and observe that the front panel meter reading is at or near center scale. If this reading is reaching the outer boundaries of the middle one-third of the scale when the green lock light is on, a trimmer adjustment should be made on the A2 circuit board in the receiver to recenter the meter reading. To obtain a center scale reading, first verify that the green lock light is lit due to an antenna signal, then adjust A2C10 to obtain a center scale reading. This is a very touchy adjustment, and must be made very slowly in extremely small increments. The long time constant in the phase locked loop will prevent the meter reading from changing rapidly, and at least 30 seconds must be allowed between adjustments for the phase locked loop to settle down. This adjustment compensates for the long-term aging of the 10 MHz crystal A2Y1 which is phase locked to the WWVB carrier frequency. In a properly functioning receiver, this adjustment should not be required more often than every 6 months.

LOCK VOLTAGE NEAR CENTER SCALE_____

If the answers to the three items on the checklist are yes, assurance is established that the receiver is operating properly, and that calibration made with it are traceable directly to the Bureau of Standards.

3.0 TEST EQUIPMENT

Table 5-1 lists the recommended test equipment for checking the performance of the Model 8163.

Test equipment with equivalent characteristics may be substituted.

INSTRUMENT	REQUIRED CHARACTERISTICS	RECOMMENDED
WWVB Antenna	60 KHz Active Antenna	Spectracom Model 8206
Oscilloscope	2-channel	Tektronix Model 455
Voltmeter	$4\frac{1}{2}$-Digit Multimeter	Data Precision Model 255
Counter	Accuracy 1×10^{-7}	HP 5315B Universal Counter
Signal Generator	60 KHz. Accuracy 1×10^{-5}. Output less than 0.2 uV	Wavetek Model 3002 Synthesizer

TABLE 5-1 RECOMMENDED TEST EQUIPMENT

4.0 TEST SET-UP

Figure 5-1 shows the test set-up. With the signal generator set to 60 KHz and connected to the ANTENNA input it simulates the signal transmitted by WWVB. To measure the sensitivity of the LOCAL INPUT amplifier the generator is set to 1 MHz and connected to the LOCAL INPUT.

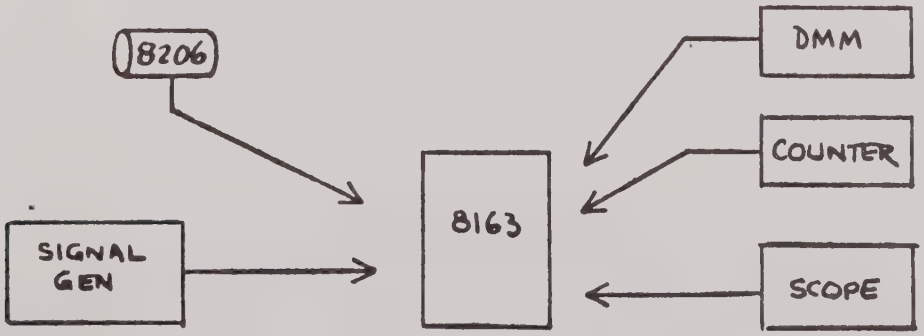

FIG. 5-1 TEST SET-UP

5.0 TEST PROCEDURES

5.1 Power Supplies

This test records the power supply voltages.

+5 Volts (±.25)	P1-11B	_____V
+12 Volts (±0.5)	U22-3	_____V
-12 Volts (±0.5)	U1-14	_____V

5.2 RF Amplifier Alignment

The purpose of this test is to tune the input transformer T1 and crystal filter C8, C9, Y1.

Disconnect the AGC wire (violet) from connector A1P2, pin 6.

Connect the oscilloscope probe to A2E1.

Set the signal generator and attenuator to provide an unmodulated 1.0 microvolt signal (RMS) at exactly 60 KHz.

Apply power to the receiver and adjust the signal generator level to provide a 1 volt peak-to-peak output signal on the oscilloscope.

Adjust the slug in the transformer, A1T1, for a peak on the oscilloscope, while reducing the signal generator to maintain a 1 volt peak-to-peak output.

INPUT VOLTAGE AT 1V P-P _____uV

Adjust capacitor A1C8 for maximum output on the oscilloscope.

TUNE CRYSTAL FILTER A1C8_____

Change the signal generator frequency to 100 KHz and increase the output for a reading of 1 volt peak-to-peak at A2E1. During this test do not exceed 0.1 volt RMS at the antenna input. Adjust capacitor A1C9 for minimum output on the oscilloscope while increasing the signal generator level to maintain a 1V peak-to-peak output.

TUNE STOP BAND NULL A1C9_____

Change the signal generator frequency to 60 KHz at a 1 millivolt RMS input level. The output waveform (A2E1) should be a square wave with a 50% ±10% duty cycle and 3 volts peak-to-peak ±20%.

OUTPUT SIGNAL A1E3, 50% duty cycle ±10%_____

OUTPUT SIGNAL A1E3, 3V p-p ±20%_____V

Change the signal generator so the input to the 8163 is 5 microvolts RMS. The output amplitude should be equal to or greater than 1.5V peak-to-peak. The output will be a sine wave until the clipping point is reached at approximately 3 volts peak-to-peak.

OUTPUT SIGNAL, A2E1, 1.5V p-p_____V

This completes the alignment of the RF Amplifier. The AGC potentiometer adjustment is described in TEST 5.9.

5.3 Quad Detector and Phase Detector Balance

This test adjusts potentiometers A2R30 and A2R5. Remove the input signal to the antenna input. Preset the adjustments on the A2 Receiver board as follows. The controls may be left as is if the receiver has been previously aligned.

1. Adjust R5, R14, R23, R30, R78, R80 to center range. Adjust C10 to center range (line the adjustment slot up with C9). Adjust the panel meter to zero using the zero adjust on the meter.

2. Connect a clip lead from A2E2 to A2E3. Connect the negative lead of the DVM to A2TP3, and the positive lead to A2TP4. Set the DVM to ±2V full scale. Make no connection to the antenna input.

3. Apply power to the receiver and adjust A2R30 for a zero reading on the DVM. Slight digit changes may be noticed, but should be less than ±5 mv. Move the positive DVM lead from A2TP4 to A2TP6. The reading should be less than ±500 mv. Glyptol A2R30.

QUAD DETECTOR BALANCE_____

4. Connect the negative DVM lead to A2TP1 and the positive lead to A2TP2. Adjust A2R5 for a zero rading on the DVM. Changes of ±5 mv or less may be noticed.

PHASE DETECTOR BALANCE_____

5.4 Lock Volts Meter Adjust

This test adjusts A2R14. Move the clip lead from A2E3 to A2E4. Set the meter switch A2S2 to read lock volts (V position). Adjust A2R14 for a meter reading of 80% full scale. Glyptol A2R14.

LOCK VOLTS (80% full scale)_____

5.5 Oscillator Adjust

Connect the frequency counter to the NBS OUTPUT on the front panel. Adjust A2C10 for a counter reading of 9,999,900 Hz.

OSCILLATOR PRESET (9,999,900 Hz)_____Hz

5.6 Oscillator Symmetry

Disconnect the clip lead from A2E2 to A2E4. Connect the front panel NBS OUTPUT to the oscilloscope. Select 10 MHz output frequency. Adjust A2R23 so the 10 MHz signal is a symmetrical square wave. Glyptol A2R23.

OSCILLATOR SYMMETRY _____-dB

5.7 Final Adjust 10 MHz Oscillator

Adjust the signal generator to 60.000 KHz unmodulated and 1 mV RMS when connected to the receiver antenna. The receiver should lock, indicated by a green lock light and a lock voltage meter reading near center scale. Adjust A2C10 very slowly until the lock voltage is exactly center scale.

5.8 Final Adjust Phase Detector Balance

Disconnect the signal generator from the antenna and note the lock voltage meter reading drift. Disregard any sudden small jump at the moment of disconnect. If a downward drift is observed then turn A2R5 clockwise by very small amounts until the drift is stopped. Small jumps may occur as A2R5 is adjusted, disregard these and only note the slow drift. If an upward drift is observed then turn A2R5 counterclockwise by very small amounts. This is a very fine adjustment and is completed when no perceptable drift is evident after one minute of observation. Glyptol A2R5.

5.9 AGC Voltage Control Adjust A1R19

Connect the negative lead of the DVM to A2TP3 and the positive lead to A2TP6. Adjust the signal generator to 60.000 KHz and 1 uV when connected to the ANTENNA input. The meter is reading the AGC voltage with the AGC feedback loop open (the AGC wire, A1P2-6, was disconnected during the testing of the RF Amplifier.) Lock-up may take several minutes at 1 uV input. The voltage at A2TP6 may continue to rise after the green lock light comes on.

Adjust the signal generator in small amounts (less than 1 dB) until the voltage is approximately +2.38 V. Wait one or more minutes between level changes. The voltage read on the DVM is delayed by a long time constant in the AGC loop. A 2.38 V reading is normally reached with an antenna input level between 0.25 and 1.0 uV.

AGC VOLTS A2TP3 to A2TP6 (2.38V)_____V

Reconnect the violet AGC wire to A1P2-6. The DVM reading will slowly decrease to a lower value. Adjust the AGC control A1R19 in very small amounts until the DVM stabilizes 1V lower or approx. +1.38 V. Wait one or more minutes between adjustments because of the long time constant in the AGC loop. Glyptol A1R19.

AGC Volts A2TP3 to A2TP6 (1.38V)_____V

5.10 Receiver Sensitivity

This test measures the receiver sensitivity. Increase the signal generator level to 10 uV and wait a minute for the receiver to stabilize. Decrease the signal generator level to 1.0 uV and allow one minute for the receiver to stabilize. The green lock light should be on. Slowly decrease the signal generator level until the red lock light comes on. Do not exceed 1 dB per 10 seconds. The signal generator level should be between 0.1 and 0.5 uV.

UNLOCK SENSITIVITY (0.1-0.5 uV)_____uV

Slowly increase the signal generator level until the green lock light comes on. Do not exceed 1 dB per 10 seconds. The level will typically be 6 dB above the unlock level and should be between 0.25 and 1.0 uV.

LOCK LEVEL (0.25-1.0 uV)_____uV

5.11 Phase Comparator Full Scale Adjustment

This test calibrates the full scale deflection of the front panel meter and the AUX OUTPUT.

Turn off the receiver and recheck the mechanical zero adjustment of the front panel meter.

Set the meter switch A2S2 to read phase difference. Set the 50/10 switch A2S1 for 10 microsecond full-scale deflection. Select 0.1 MHz input frequency on the front panel FREQ select switch. Connect the NBS OUTPUT to the LOCAL INPUT. Adjust A2R78 for full scale deflection of the front panel meter. Glyptol A2R78.

CALIBRATE FRONT PANEL METER
(A2R78) _____

If an external 0 to 1 mA recorder is used, connect it to the AUX OUTPUT. Adjust A2R80 for full-scale deflection on the external recorder. Only 0 to 1 mA devices whose DC resistance is less than 1500 ohms can be calibrated. Glyptol A2R80.

CALIBRATE EXTERNAL RECORDER
(A2R80) _____

DISCONNECT THE CLIP LEAD FROM A2TP7 TO CHASSIS

5.12 Measure LOCAL INPUT Sensitivity

This test measures the sensitivity of the LOCAL INPUT amplifier. Install the Model 8206 and achieve phase lock with WWVB. Depress the 1 MHz select FREQ switch on the front panel. Connect the signal generator to the LOCAL INPUT. Set the input signal to 1.0 MHz at 100 mV. The meter will show the relative phase drift between the two signals.

Decrease the signal level into the LOCAL INPUT until the phase comparator operation becomes erratic. Increase the level until stable operation is attained. Record the level of the input signal.

LOCAL INPUT Sensitivity_____mV
(less than 100 mv)

5.13 NBS OUTPUT

Connect the oscilloscope to the NBS OUTPUT connector through a short coax cable. Depress the 0.1 MHz FREQ select switch and observe that the waveform is a TTL-compatible rectangular square wave. Repeat by selecting 1.0, 5.0, and 10.0 MHz.

NBS OUTPUT 0.1 MHz (>2.7V)_____V
NBS OUTPUT 1.0 MHz (>2.7V)_____V
NBS OUTPUT 5.0 MHz (>2.7V)_____V
NBS OUTPUT 10.0 MHz(>2.7V)_____V

5.14 Antenna Voltage Measurement

Connect the antenna to the receiver through a BNC T-connector. With the antenna connected to the receiver measure the DC voltage at the ANTENNA input.

ANTENNA VOLTAGE (2.0V ±0.2)_____V

5.15 Signal Strength Measurement

After the antenna has been installed and connected to the Model 8163, measure the AGC voltage. Connect the negative lead of the DVM to A2TP3 and the positive lead to A2TP6. Record the voltage. Maximize this voltage by experimenting with antenna location and orientation. The receiver will lock on the signal when the AGC voltage is greater than 1.0 volts.

AGC VOLTS (>1.0 V) _____V

5.16 Model 8206 Antenna

This test verifies the proper operation of the Model 8206 Loop Antenna. It may be omitted if the above tests were completed satisfactorily.

Figure 5-2 shows the test set-up for testing the antenna. Connect a coax cable to the signal generator. Wrap 2 turns of wire around the antenna. Connect one side of the wire to the center conductor of the coax through a 1K resistor. Connect the other side to the shield.

Adjust the signal generator for an output of .014 V RMS into the 1K load. If the signal generator has a calibrated output that expects a 50-ohm load then adjust the output level to .007 V RMS.

Feed +12V to the antenna through a 27K resistor. AC couple the antenna to the scope.

Find the resonant frequency of the antenna by adjusting the signal generator frequency for maximum output signal. The resonant frequency should be 60.0 ± .3 KHz.

RESONANT FREQUENCY 60.0 ± .3 KHz_____KHz

The amplitude of the output signal should be approximately 0.010 V peak-to-peak.

ANTENNA OUTPUT (.010 V p-p)_____V

Determine the antenna bandwidth. Increase the signal generator frequency until the output amplitude is half the resonant frequency amplitude. Decrease the signal generator frequency until the output amplitude is half the resonant frequency amplitude. Make sure that the amplitude of the input signal remains constant during this test. The antenna bandwidth is the difference in the two figures.

ANTENNA BANDWIDTH (1 KHz)_____KHz

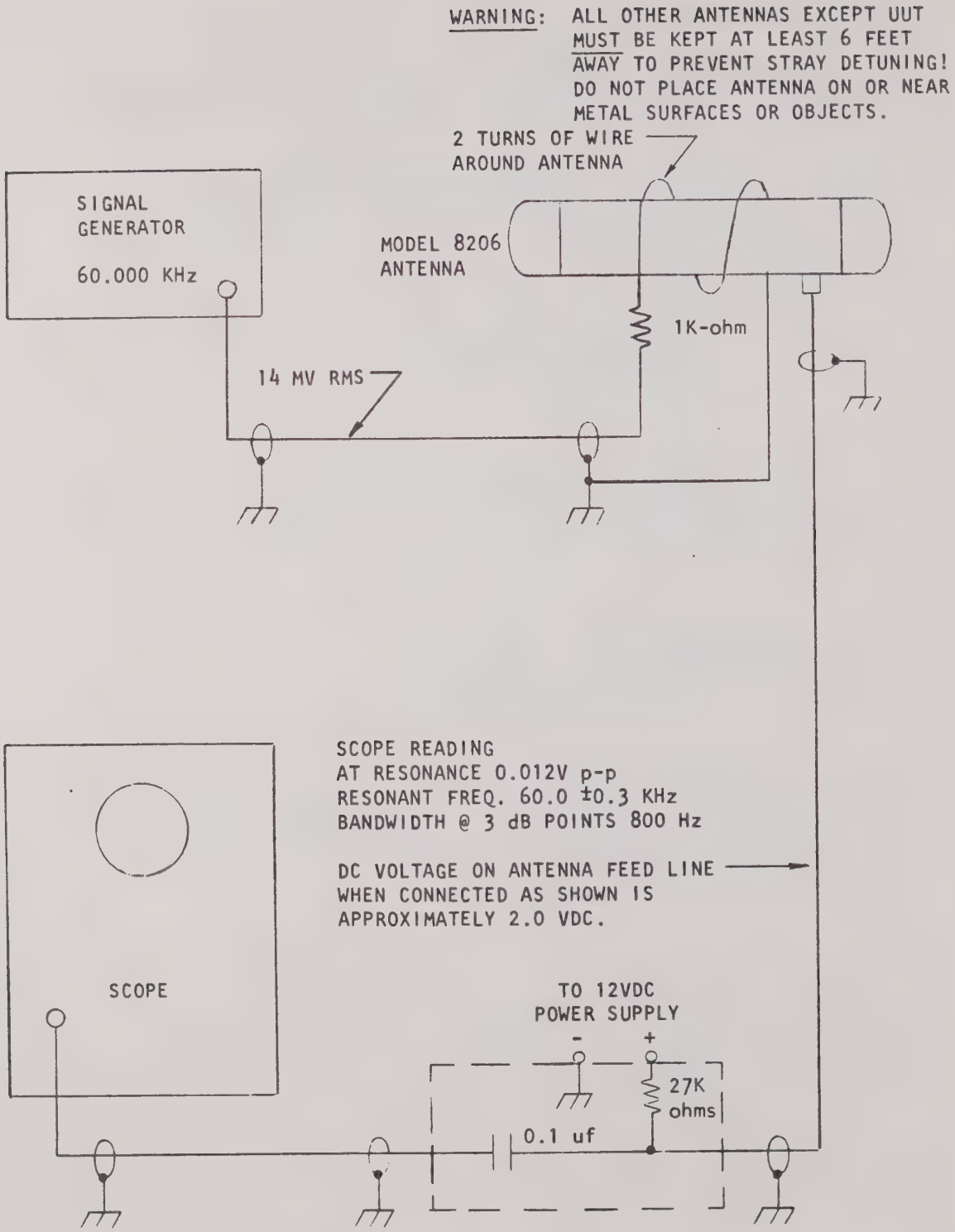
WARNING: ALL OTHER ANTENNAS EXCEPT UUT MUST BE KEPT AT LEAST 6 FEET AWAY TO PREVENT STRAY DETUNING! DO NOT PLACE ANTENNA ON OR NEAR METAL SURFACES OR OBJECTS.
2 TURNS OF WIRE AROUND ANTENNA
SIGNAL GENERATOR
60.000 KHz
MODEL 8206 ANTENNA
1K-ohm
14 MV RMS
SCOPE READING
AT RESONANCE 0.012V p-p
RESONANT FREQ. 60.0 ±0.3 KHz
BANDWIDTH @ 3 dB POINTS 800 Hz
DC VOLTAGE ON ANTENNA FEED LINE WHEN CONNECTED AS SHOWN IS APPROXIMATELY 2.0 VDC.
SCOPE
TO 12VDC POWER SUPPLY
-
+
27K ohms
0.1 uf

FIG. 5-2 ANTENNA MODEL 8206 TEST SETUP

6.0 MODEL 8207 PREAMP ALIGNMENT

The Model 8207 Antenna Preamplifier is a low noise, tuned, 60 KHz line amplifier used in the antenna feed line wherever the WWVB signal strength is less than 0.3uV at the receiver antenna terminator.

The purpose of this test is to tune the preamp to 60 KHz.

Perform the receiver alignment as described in Section 5.0.

Set the receiver A1S1 switch in the receiver to the preamp (P) (right) position.

Use RG-58 coax to connect the preamp between the signal generator and the WWVB Receiver as shown in Figure 5-3.

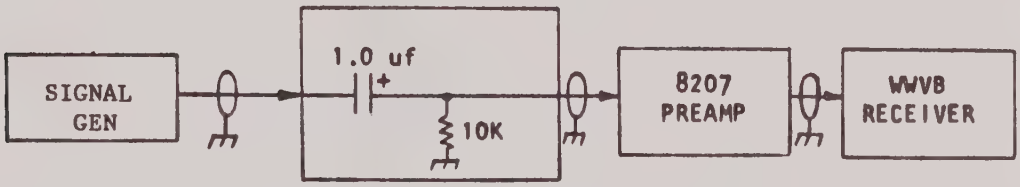

FIG. 5-3 MODEL 8207 PREAMPLIFIER ALIGNMENT

Physically separate the preamp from the receiver by at least 10 feet. Keep the cable from the signal generator to the preamp away from the vicinity of the receiver to prevent signal regeneration.

In the receiver, disconnect the AGC wire (violet) from Connector A1P2, Pin 6, but leave the remaining wires in place and the connector mated.

Connect an oscilloscope probe to A1E3. Set the scope for AC coupling. The ground lead is connected to the chassis.

Set the generator to provide a 1.0 uV signal at exactly 60,000 Hz, unmodulated.

Apply power to the receiver and adjust the signal generator level as necessary to provide a 1 volt P-P output signal on the oscilloscope.

Adjust the slug in transformer A1T1 in the Model 8207 for a peak on the oscilloscope, while reducing the signal generator level to maintain the 1 V P-P output.

PREAMP TUNED_____

SECTION 6

8163

REPLACEABLE PARTS LIST

This section lists the reference designation, part number, and description of each replaceable part.

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
Final Assembly	F1	F00R12	Fuse, .12A, 3AG
	F2	F00R37	" , 3/8A, 3AG
	XF1	X00060	Fuseholder
	XF2	"	"
Main Frame	A1	001100	RF Amplifier Assembly
	A2	008200	Receiver Assembly
Harness Assembly	P2	P00112	Connector, 12 pins
	P3	"	"
	P2-P3	P00100	Pin, terminal
	P2-P3	P00300	Key, polarizing
Front Panel Assembly	DS1	DS00042	Display, LED
	DS2	DS00045	"
	J1	J00002	Receptacle, BNC
	J2	J00010	"
	J3	"	"
	J4	J01030	Panel phone jack
	M1	M00001	Meter
	R1	R09503	Potentiometer, 50K, 10-turn
	S1	S00004	Switch,
A1, RF Amplifier	C1	C12226	Capacitor, Tant, 22 uf, 15V
	C2	C06182	" , Mica, 1800 pf
	C3	C15105	" , Tant, 1 uf, 35V
	C4	"	"
	C5	"	"
	C6	C12226	" Tant, 22 uf 15V
	C7	C05820	" Mica, 82 pf
	C8	C00022	" Trimmer, 5-25 pf
	C9	"	"
	C10	C05050	" Mica, 5 pf
	C11	C15105	" Tant, 1 uf, 35V
	C12	C12226	" Tant, 22 uf, 15V
	C13	C15105	" Tant, 1 uf, 35V
	C14	C18103	" Polystyrene, .01 uf
	C15	"	"
	C16	C01104	" Disc, 0.1 uf
	C17	C15105	" Tant, 1 uf, 35V
	C18	C12226	" Tant, 22 uf, 15V
	C19	C15105	" Tant, 1 uf, 35V
	C20	"	"
	C21	"	"
	C22	C12226	" Tant 22 uf, 15V
	C23	C06182	" Mica, 1800 PF
	L1	L03102	Choke, 1000 uH
	L2	"	"
	L3	L03331	" 330 uH
	P1	J00002	Receptacle, BNC for RG-316
	P2	P00106	Plug Body, 6 pins
	P2	P00100	Contacts
	P2	P00300	Key, polarizing

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A1, RF Amplifier	Q1	Q04126	Transistor, 2N4126
	Q2	Q04124	" 2N4124
	Q3	"	"
	R1	R01562	Resistor, ¼w, 5%, 5.6 K
	R2	R01273	" 27 K
	R3	R01393	" 39 K
	R4	R01183	" 18 K
	R5	R01153	" 15 K
	R6	R01152	" 1.5 K
	R7	R01123	" 12 K
	R8	R01332	" 3.3 K
	R9	"	"
	R10	"	"
	R11	R01183	" 18 K
	R12	"	"
	R13	R01123	" 12 K
	R14	R01683	" 68 K
	R15	R01561	" 560 ohm
	R16	R01681	" 680 ohm
	R17	R01390	" 39 ohm
	R18	R01100	" 10 ohm
	R19	R05503	Potentiometer, 50 K
	R20	R01222	Resistor, ¼w, 5%, 2.2 K
	S1	S00102	Switch, Slide, 2 pole
	T1	T00020	Transformer
	U1	U01350	Integrated Circuit MC1350P
	U2	"	"
	Y1	Y00000	Crystal, Quartz, 60 KHz
A2, Receiver Assy	C1	C01104	Capacitor, Disc, 0.1 uf, 25V
	C2	C15105	" Tant, 1 uf, 35V
	C3	C01104	" Disc, 0.1 uf, 25V
	C4	C00100	" Tant, 120 uf, 15V
	C5	C02103	" Disc, .01 uf, 50V
	C6	C12226	" Tant, 22 uf, 15V
	C7	"	"
	C8	C05560	" Mica, 56 pf
	C9	C05200	" Mica, 20 pf
	C10	C00021	" Trimmer, 3-12 pf
	C11	C05301	" Mica, 300 pf
	C12	"	"
	C13	C01104	" Disc, 0.1 uf, 25V
	C14	C18472	" Polystyrene, 4700pf, 160V
	C15	"	"
	C16	C15105	" Tant, 1.0 uf, 35V

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A2, Receiver Assy	C17	C12226	Capacitor, Tant, 22 uf, 15V
	C18	"	"
	C19	C15105	" Tant, 1.0 uf, 35V
	C20	C01104	" Disc, 0.1 uf, 25V
	C21	C15105	" Tant, 1.0 uf, 35V
	C22	C10157	" Tant, 150 uf, 6V
	C23	C12226	" Tant 22 uf, 15V
	C24	C02103	" Disc, .01 uf, 50V
	C25	"	"
	C26	"	"
	C27	"	"
	C28	"	"
	C29	"	"
	C30	"	"
	C31	C01104	" Disc, 0.1 uf 25V
	C32	"	"
	C33	"	"
	C34	C12226	" Tant, 22 uf, 15V
	C35	"	"
	C36	C02103	" Disc, .01 uf, 50V
	C37	"	"
	C38	Not used	
	C39	C05910	" Mica, 91 pf
	C40	"	"
	C41	C02103	" Disc, .01 uf, 50V
	C42	"	"
	C43	"	"
	C44	C18392	" Polystyrene, 3900pf,160V
	C45	C18751	" Polystyrene, 750pf,160V
	C46	C18392	" Polystyrene, 3900pf,160V
	C47	C02103	" Disc, .01 uf, 50V
	C48	"	"
	C49		"
	C59	C15105	" Tant, 1.0 uf, 35V
	C60	"	"
	CR1	CR04148	Diode, 1N4148
	CR2	CR00209	Voltage Variable Capacitor,MV-209
	CR3	CR05059	Diode, 1N5059
	CR4	CR04148	Diode, 1N4148
	CR5	Not Used	
	CR6	CR04148	Diode, 1N4148
	CR7	"	"

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A2, Receiver Assy	CR16	CR04148	Diode, 1N4148
	E1	E02320	Terminal, turret
	E2	"	"
	E3	"	"
	E4	"	"
	J1	J00106	Receptacle - 6 pin
	J2	"	"
	J3	"	"
	L1	L03152	Choke, 1500 uH
	L2	"	"
	L3	"	"
	Q1	Q04126	Transistor, 2N4126
	Q2	"	"
	Q3	Q04124	" 2N4124
	Q4	Q04258	" 2N4258
	Q5	Q04126	" 2N4126
	Q6	Q04258	" 2N4258
	Q7	"	"
	Q8	Q04126	" 2N4126
	Q9	Q04124	" 2N4124
	R1	R01471	Resistor, ¼w, 5%, 470 ohms
	R2	R01561	" 560 ohms
	R3	"	"
	R4	R01472	" 4.7 K
	R5	R05202	Potentiometer, Trimming,Cermet, 2K
	R6	R21512	Resistor, Metal Glaze, ¼w, 2%, 5.1K
	R7	R21562	" 5.6K
	R8	"	"
	R9	R01393	Resistor, ¼w, 5%, 39 K
	R10	"	"
	R11	R01104	" 100 K
	R12	R01102	" 1 K
	R13	R01472	" 4.7 K
	R14	R05502	Potentiometer, Trimming, Cermet, 5K
	R15	R01272	Resistor, ¼w, 5%, 2.7 K
	R16	R01562	" 5.6 K
	R17	"	"
	R18	R01104	" 100 K
	R19	R01393	" 39 K
	R20	R01153	" 15 K
	R21	R01332	" 3.3 K
	R22	R01330	" 33 ohms
	R23	R05202	Potentiometer, Trimming, Cermet, 2K

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A2, Receiver Assy	R24	R01331	Resistor, ¼w, 5%, 330 ohms
	R25	R01471	" 470 ohms
	R26	R01561	" 560 ohms
	R27	"	"
	R28	R01472	" 4.7 K
	R29	R01152	" 1.5 K
	R30	R05202	Potentiometer, Trimming, Cermet, 2K
	R31	R21512	Resistor, Metal Glaze ¼w, 2%, 5.1K
	R32	R21562	" 5.6K
	R33	"	"
	R34	R01472	Resistor, ¼w, 5%, 4.7 K
	R35	R01332	" 3.3 K
	R36	R01153	" 15 K
	R37	"	"
	R38	R21154	Resistor, Metal Glaze, ¼w, 2%, 150K
	R39	R21153	" 15 K
	R40	R21154	" 150K
	R41	Not used	
	R42	R01153	Resistor,,¼w, 5%, 15 K
	R43	R01475	" 4.7 megaohms
	R44	R01332	" 3.3 K
	R45	R01473	" 47 K
	R46	R01563	" 56 K
	R47	R01394	" 390 K
	R48	R01105	" 1 megaohm
	R49	R01332	" 3.3 K
	R50	R01221	" 220 ohms
	R51	R01103	" 10 K
	R52	"	"
	R53	R01151	" 150 ohms
	R54	R01332	Resistor, ¼w, 5%, 3.3 K
	R55	R01560	" 56 ohms
	R56	"	"
	R57	Not Used	
	R58	R01101	Resistor, ¼w, 5%, 100 ohms
	R59	R01682	" 6.8 K
	R60	R01471	" 470 ohms
	R61	"	"
	R62	R01391	" 390 ohms
	R63	R01152	" 1.5K
	R64	Not Used	

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A2, Receiver Assy	R65	R01102	Resistor, ¼w, 5%, 1 K
	R66	Not used	
	R67	"	
	R68	"	
	R69	R01272	" 2.7 K
	R70	"	"
	R71	"	"
	R72	R01822	" 8.2 K
	R73	"	"
	R74	R01102	" 1 K
	R75	R01104	" 100 K
	R76	"	"
	R77	R01272	" 2.7 K
	R78	R05502	Potentiometer, Trimming, Cermet, 5K
	R79	R01272	Resistor, ¼W, 5%, 2.7 K
	R80	R05502	Potentiometer, Trimming, Cermet, 5K
	R81	R01101	Resistor, ¼w, 5%, 100 ohms
	R82	Not Used	
	R83	R01272	" 2.7 K
	R84	Not Used	
	R85	R01682	Resistor, ¼w, 5%, 6.8 K
	R86	R01182	" 1.8 K
	R87	Not Used	
	R88	R01152	" 1.5 K
	R89	R21153	Resistor, Metal Glaze, ¼w,5%,15K
	R90	"	
	R91	R21103	" , Metzl Glaze, ¼w,2%,10K
	R92	R013R9	" ,¼w, 5%, 3.9
	R93	R01101	" , ¼w, 5%, 100 ohms
	R94	"	
	R95	R03102	" , 1w, 5%, 1K
	S1	S00102	Switch, Slide
	S2	"	
	TP1	TP00001	Test Point, Brown
	TP2	TP00002	" , Red
	TP3	TP00003	" , Orange
	TP4	TP00004	" , Yellow
	TP6	TP00006	" , Blue
	TP8	TP00008	Not used.
	U1	U01496	Integrated Circuit, LM1496N
	U2	U00324	" LM324N
	U3	U01496	" LM1496N
	U4	U00339	" LM339N
	U5	U4LS37	" SN74LS37
	U6	U4S140	" SN74S140
	U7	U4LS37	" SN74LS37

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A2, Receiver Assy	U8	U4LS90	Integrated Circuit, SN74LS90
	U9	"	"
	U10	"	"
	U11	U4S132	" , SN74S132
	U12	U4LS20	" , SN74LS20
	U13	U4LS90	" , SN74LS90
	U14	"	"
	U15	U4LS37	" , SN74LS37
	U16	U4LS90	" , SN74LS90
	U17	Not Used	
	U18	U4LS37	" , SN74LS37
	U19	Not Used	
	U20	U4LS90	" , SN74LS90
	U21	U78L05	Voltage Regulator, 75L05AWC
	U22	U00723	" , UA723C
	VR1	Not Used	
	VR2	VR04735	Zener Diode, 1N4735A
	VR3	VR05242	" , 1N5242
	Y1	Y00011	Crystal, Quartz

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A2, Receiver Assy	R65	R01102	Resistor, ¼w, 5%, 1 K
	R66	Not used	
	R67	"	
	R68	"	
	R69	R01272	" 2.7 K
	R70	"	"
	R71	"	"
	R72	R01822	" 8.2 K
	R73	"	"
	R74	R01102	" 1 K
	R75	R01104	" 100 K
	R76	"	"
	R77	R01272	" 2.7 K
	R78	R05502	Potentiometer, Trimming, Cermet, 5K
	R79	R01272	Resistor, ¼W, 5%, 2.7 K
	R80	R05502	Potentiometer, Trimming, Cermet, 5K
	R81	R01101	Resistor, ¼w, 5%, 100 ohms
	R82	Not Used	
	R83	R01272	" 2.7 K
	R84	Not Used	
	R85	R01682	Resistor, ¼w, 5%, 6.8 K
	R86	R01182	" 1.8 K
	R87	Not Used	
	R88	R01152	" 1.5 K
	R89	R21153	Resistor, Metal Glaze, ¼w,5%,15K
	R90	"	
	R91	R21103	" , Metzl Glaze, ¼w,2%,10K
	R92	R013R9	" ,¼w, 5%, 3.9
	R93	R01101	" , ¼w, 5%, 100 ohms
	R94	"	
	R95	R03102	" , 1w, 5%, 1K
	S1	S00102	Switch, Slide
	S2	"	
	TP1	TP00001	Test Point, Brown
	TP2	TP00002	" , Red
	TP3	TP00003	" , Orange
	TP4	TP00004	" , Yellow
	TP6	TP00006	" , Blue
	TP8	TP00008	Not used.
	U1	U01496	Integrated Circuit, LM1496N
	U2	U00324	" LM324N
	U3	U01496	" LM1496N
	U4	U00339	" LM339N
	U5	U4LS37	" SN74LS37
	U6	U4S140	" SN74S140
	U7	U4LS37	" SN74LS37

PARTS LIST

ASSEMBLY	REFERENCE DESIGNATION	PART NUMBER	DESCRIPTION
A2, Receiver Assy	U8	U4LS90	Integrated Circuit, SN74LS90
	U9	"	"
	U10	"	"
	U11	U4S132	" , SN74S132
	U12	U4LS20	" , SN74LS20
	U13	U4LS90	" , SN74LS90
	U14	"	"
	U15	U4LS37	" , SN74LS37
	U16	U4LS90	" , SN74LS90
	U17	Not Used	
	U18	U4LS37	" , SN74LS37
	U19	Not Used	
	U20	U4LS90	" , SN74LS90
	U21	U78L05	Voltage Regulator, 75L05AWC
	U22	U00723	" , UA723C
	VR1	Not Used	
	VR2	VR04735	Zener Diode, 1N4735A
	VR3	VR05242	" , 1N5242
	Y1	Y00011	Crystal, Quartz

FLUKE ELECTRONICS CANADA INC.

[X] MISSISSAUGA
400 BRITANNIA RD.
UNIT # 1
MISSISSAUGA, ONTARIO
L4Z 1X9
TEL: (416) 890-7600
FAX: (416) 890-6866

[ ] OTTAWA
1690 WOODWARD DR.
SUITE 216
OTTAWA, ONTARIO
K2C 3R8
TEL: (613) 723-9453
FAX: (613) 723-9458

[ ] MONTREAL
1255 TRANS CANADA HWY.
SUITE 120
DORVAL, QUEBEC
H9P 2V4
TEL: (514) 685-0022
FAX: (514) 685-0039

[ ] CALGARY
1144 - 29th AVE. N.E.
SUITE 101
CALGARY, ALBERTA
T2E 7P1
TEL: (403) 291-5215
FAX: (403) 291-5219

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HONEYWELL-SPERRY AEROSPACE
HWY #17, P.O. BOX 1300
ROCKLAND ONT
KOA 3AO

DIVISION HONEYWELL LTD

SHIP TO / EXPÉDIER À

HONEYWELL-SPERRY AEROSPACE
3 HAMILTON AVE
OTTAWA ONT
K1Y 4J4

13:59:54

R ORDER NUMBER TRE NO. DE COMMANDE	SALES REP. VENDEUR		TERMS - TERMES	INVOICE NUMBER NO. DE LA FACTURE	INVOICE DATE DATE DE LA FACTURE
NF1173	76N		NET 30 DAYS NET 30 JOURS	107759	11 OCT 88
STOMER ORDER NUMBER DE DE COMMANDE DU CLIENT		**LOCATION**	**FREIGHT ACCT. CODE**	**PACKING LIST NUMBER NO. DE LA B. D'EXP.**	**PACKING LIST DATE DATE DE LA B. D'EXP.**
91784					
RRIER - TRANSPORTEUR	**FREIGHT - FRET**		**C.O.D. AMOUNT MONTANT C.R.**	**AMOUNT OF INSURANCE MONTANT DE L'ASSURANCE**	**F.O.B. - F.A.B.**
PUR PPD			NIL	NIL	DEST

TEM RTICLE	S.C.	PRODUCT / DESCRIPTION / SERIAL NUMBER PRODUIT / DESCRIPTION / NO. DE SÉRIE	QTY. ORD. QTÉ. COMM.	QTY. SHIP. QTÉ. EXP.	QTY. B.O. QTÉ. C.S.E.
001	SM	8163 WWVB RECEIVER/COMPARATOR ** SERIAL NUMBERS ** 8163-0748	1	1	0
002	SM	8206 LOOP ANTENNA ** SERIAL NUMBERS ** 8206-2058	1	1	0
003	SM	8211 ANTENNA MOUNT	1	1	0

****** COMMENTS ******
**2 R E C E I V I N G S ** LOCATIONS,
A2 & A5

REV. 07/88

E. & O.E

PACKING LIST – BON D' EXPÉDITION

		****** COMMENTS ******			
002	SW	8511 ANTENNA MOUNT 8509-3028 ** SERIAL NUMBERS **	1	1	
003	SW	8509 LOOP ANTENNA 8192-0148 ** SERIAL NUMBERS **	1	1	
001	SW	8192 MMWB RECEIVER/COMPARATOR	1	1	

PACKING LIST – BON D. EXPEDITION

HONEYWELL-SPERRY AEROSPACE
P.O. BOX 1200
HONEYWELL LTD
DIVISION HONEYWELL LTD
SHIP TO / EXPEDIER A
HONEYWELL-SPERRY AEROSPACE
DOWNSVIEW ONT
M3J 2S9
KEY DATA
DOWNSVIEW ONT
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